ATTACHMENT 6

Southern California Edison Company, El Segundo Generating Station Thermal Effect Study Final Report. Dated July 1973

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SOUTHERN CALIFORNIA EDISON COMPANY
EL SEGUNDO GENERATING STATION
THERMAL EFFECT STUDY
FINAL REPORT

Prepared for:

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By

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MARINE BIOLOGY RESEARCH GROUP
ELECTROCHEMISTRY DEPARTMENT
LOCKHEED AIRCRAFT SERVICE COMPANY
A Division of Lockheed Aircraft Corporation
LOCKHEED OCEAN LABORATORY - SAN DIEGO, CALIFORNIA

STATEMENT OF CERTIFICATION

I declare under penalty of perjury that (to the best of my knowledge and belief) the foregoing is true and correct.

Executed on the 20th day of July, 1973, at San Diego, California.

Peter H. Benson Peter H Benson

Senior Scientist
Title of Declarer

PREFACE

Environmental impact studies are multidisciplinary and require a well-rounded team of specialists to achieve optimal results. Such a team, composed entirely of Lockheed scientists, has been used effectively during the year-long study reviewed herein. This highly qualified team includes marine biologists, marine geologists, and biological and physical oceanographers, all conveniently located at the same facility: the Lockheed Ocean Laboratory in San Diego, California.

The study, conducted by the Lockheed Aircraft Service Company (LAS), with assistance from the Lockheed-California Company (Calac) and Lockheed Missiles and Space Company (LMSC), was performed in two distinct but integral phases: a biological monitoring phase and a physical thermal monitoring phase.

Dr. P.H. Benson of LAS, the overall Program Manager, coordinated both phases and served as principal scientist during the biological phase performed by LAS scientists. D.L. Brining served as assistant program manager and cruise chief during the biological phase of the November 1971, and May and August 1972 surveys. D.W. Perrin served as cruise chief for the biological phase of the November 1972 survey. The LAS field team consisted primarily of D.L. Brining, J.W. Graham, and D.W. Perrin. Statistical analyses were applied to the biological data by R.W. Moncreiff and computer programming was done by J.W. Graham. Shery Medler and Stephanie Perrin assisted during data analysis, report writing and editing.

The thermal monitoring phase was conducted by Calac and LMSC scientists under the management of Dr. L. Baer. The field team for the physical phase consisted of Dr. L. Baer, W.R. Richardson, D.P. Hamm, J.G. Wilder, W. Lucas, L.C. Adamo (who served as cruise chief during the first survey), J.C. Roque (cruise chief for the second survey), and Dr. R.W. Severance, (cruise chief for the third and fourth surveys). W.K. Tripp served as master of the R.V. *Sea Quest* during November 1971, and M. Wills served as master for the following surveys, aided by M. Ward in August 1972. W.R. Richardson was responsible for the design and construction of the digital system and J.C. Roque was in charge of sensor systems. Jean Hosmer, R.F. Erickson, and J.G. Wilder collected and analyzed much of the physical data, and aided in report compilation. D.P. Hamm designed the systems computer program and supervised computer activities for all surveys.

We would also like to acknowledge the cooperation and assistance of R.L. Miller, A.R. Strachan and S.A. Wiegman of the Southern California Edison Company during this study.

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FINAL REPORT CONCLUSIONS

A. INTRODUCTION

This final report presents the results of thermal effect studies conducted for the Southern California Edison Company at their El Segundo Generating Plant during November, 1971; May, August, and November 1972. The studies complied with specifications issued by the California Regional Water Quality Control Board, Los Angeles Region in September 1971 and revised on November 22, 1971.

B. PHYSICAL PHASE

1. The effect of the Southern California Edison heat addition at a distance of 1000 feet from the outfalls exceeded natural temperature by 4°F only during the May survey. This exception was attributed to an additional thermal input from another source.
2. The area's current pattern can be described as light and variable, and it does not appear to be a major factor in dispersing the heat.
3. The thermal patterns, as represented by contours of constant temperature, are highly variable in time and do not appear to be correlated with air temperature or tidal phase.
4. Two factors were observed to have obvious effects on the El Segundo thermal pattern; the thermal addition from a nearby outfall, and the mixing effect of large swells. Large swells are extremely effective in mixing the water, thereby dispersing the heat.
5. The outfalls do significantly affect the temperature of a very limited area of Santa Monica Bay. Surface water heated 1°F above natural covered a mean of 39.0 acres. The area enclosed by a 4°F excess was usually too small to measure (less than 10 acres) with the exception of May when it reached 15 acres. This increase was attributed to the influence of some outside heat source.
6. The temperature-depth profiles can be rougly classified as those having uniform temperature below the thermocline, and those having a steady decline in temperature with depth.
7. No shoreline impingement of heated water was detected and the bulk of evidence indicated that heated water does not contact the substrate.
8. The heat added from the Southern California plant at El Segundo represents a minor contribution to the total heat budget of Santa Monica Bay.

differed significantly with depth but not along isobaths. The greatest variability encountered in median sand grain size occurred at the 15-foot and 30-foot stations while median grain size at the 45-foot stations remained relatively uniform throughout the year.

7. It appears that benthic populations at El Segundo are responding to a depth related stress gradient. At shallow water stations, where seasonal variation in physical factors exhibits the greatest amplitude, a primarily physically controlled community, characterized by a low species diversity was encountered. As depth increased and seasonal amplitude in physical factors was reduced, a shift to a biologically accommodated community, characterized by relatively uniform physical conditions and a high species diversity, was disclosed.
8. H_2S odor was observed at benthic stations throughout the study, with the highest percentage occurring at stations along the 600-foot north transect. When considering depth, stations along the 30-foot isobath had the highest percent occurrence of H_2S odor. Similar observations were noted for the presence of a filamentous-organic, oil debris.
9. The overall pattern revealed by correlation analysis and ANCOVA was that depth and season were the most important factors affecting the distributions of benthic organisms. Sand grain size and bottom temperature were also important, primarily because of their dependence upon season and/or depth.

Trawl Survey

1. A total of 12,812 fish representing 47 species and 20 families, all typical of the Southern California Bight, were collected during trawl surveys.
2. Twenty-five species of fish (7,872 individuals) were captured in the study area while 45 species (4,938 individuals) were collected in the control area. Significantly more species of fish occurred in the control area; however, no significant difference between the number of individuals per area was disclosed.
3. Two fish species appeared to be exclusive to the study area and 22 were collected only in the control area. These species however, were rarely encountered in either area and when present, occurred only in very low numbers.
4. Nine species of fish numerically dominated the entire study, comprising 95 percent of the total catch. The norther anchovy (*Engraulis mordax*) exhibited an overwhelming dominance, yielding 58 percent of the total catch.
5. Only two of the dominant fish species, the white sea perch (*Phanerodon furcatus*) and the walleye surfperch (*Hyperprosopon argenteum*) exhibited significantly different abundances between study and control areas. Both occurred in greater numbers in control area catches.
6. Fifty-two species of macro-invertebrates, totaling 1,981 individuals were collected during the entire study. Thirty-five species (900 individuals) were captured in the study area and 44 species (1,081 individuals) were collected in the control area. Trivial differences between macro-invertebrate distributions did not warrant statistical analysis.

3. Numerical abundances of *Emerita* and *Excirolana* fluctuated over the study period, displaying greater variability between the two November studies than between different seasons. Analysis of covariance revealed that distance from the outfall did not influence abundances of either species during any survey.
4. Comparison of size classes of *Emerita* recorded over the survey period revealed that greater variability in population size structure also occurred between the November surveys than between the other surveys, and that populations collected north and south of the outfall were similar.
5. Intertidal water temperatures ranged from 62.4°F in November 1972 to 71.6°F in August 1972. Results of analysis of covariance on the combined data from all quarterly surveys revealed that temperature did not differ with distance from the outfall. Temperature also had no influence upon the abundance of *Emerita*, and the slight (non-significant) influence it had upon *Excirolana* was related to season.
6. Intertidal species diversity ranged from 0.00 (at the 300-foot south transect) in November 1971 to 0.989 (at the 300-foot south transect) in August 1972. Analysis of covariance revealed that species diversity was not affected by temperature and/or distance from the outfall.
7. In general, median sand grain size varied with both position on the beach (zone) and season, but not with distance from the outfall.

Dive Survey

1. Thirty species of macro-invertebrates, representative of six major taxonomic groups, were observed during the dive surveys. Ten of these species constituted 96.7 percent of the total number of individuals reported during the year.
2. Consistent with the benthic survey, species diversities increased with depth during all 1972 diver surveys and the least variability in diversity was exhibited at the 45-foot stations. The highest species diversity values occurred in August 1972.
3. Sediment and bottom water temperatures decreased with depth during all surveys. Similar findings were reported in the benthic survey. As would be expected, the highest temperatures at all depths occurred during the August 1972 survey and the 45-foot stations exhibited the least temperature variability. There appeared to be no significant temperature difference between stations along the same isobath.
4. The presence of the filamentous-oil debris and H_2S odor fluctuated with station and season, exhibiting no consistent pattern.
5. Substrate characteristics remained generally uniform along isobaths throughout the year, with ripple marks oriented in a southeasterly direction during all surveys.

I. INTRODUCTION

A. PURPOSE OF THE STUDY

This study was conducted in compliance with specifications set forth by the Los Angeles Regional Water Quality Control Board for Southern California Edison Company's El Segundo Generating Plant. The specifications outline procedures for two distinct but nevertheless integral phases: (1) a thermal monitoring phase to define the degree and areal distribution of thermal loading, and (2) a biological monitoring phase to establish possible cause/effect relationships between the area's localized temperature increase and its biological community structure.

In many cases it is not certain that localized temperature increase at power plant discharges has any effect, detrimental or beneficial, upon the surrounding marine ecosystem. Most thermal investigations of marine organisms are of limited value due to their short-term exposures and emphasis upon lethal temperatures or tolerance limits of a few specific organisms. Furthermore, they are conducted under controlled, laboratory conditions and thus have little relevance to what is occurring in the natural habitat. With the predicted future demands for electrical power, it is of utmost importance to conduct field studies within areas of thermal increase, to adequately monitor conditions in these areas over extended periods, and to obtain quantitative data from which it is possible to predict the consequences of projected thermal additions.

B. LOCATION OF THE STUDY AREA

The El Segundo study area, located approximately 33° 55′ N, 118° 26′ W, is on the sandy beach shore of Santa Monica Bay, Southern California (see Figure I-1). The El Segundo Generating Station is situated within the City of El Segundo, County of Los Angeles, approximately midway between Imperial Boulevard and Rosecrans Avenue.

Immediately adjacent to the El Segundo Station is the Standard Oil of California – El Segundo Refinery. Approximately one mile north of the study site is another sub-aqueous thermal discharge from the City of Los Angeles' Scattergood Steam Plant.

II. PHYSICAL PHASE

A. INTRODUCTION

Between November 1971 and February 1973, Lockheed conducted a thermal monitoring program of the receiving waters surrounding Southern California Edison's El Segundo power generating plant's cooling water discharge. The surveys and reporting were carried out in accordance with directives of the Los Angeles Regional Water Quality Control Board. This portion of the final report summarizes the results of five quarterly thermal surveys and seven monthly surveys. The reduced data from the February 1973 quarterly survey has not been previously published and is included in Appendix II-A. Earlier reports (Benson, 1972; Benson, *et al.*, 1972*a*, 1972*b*, 1973) contain interim conclusions which are discussed and summarized in this report.

B. METHODS AND MATERIALS

Lockheed's approach to the study of small-scale temperature structures in near-shore ocean waters was to record temperatures from several depths every two seconds together with precise observations of time and position. To manipulate such large volumes of data, the information was recorded on magnetic tape in a computer-compatible format.

Precision navigation was provided by Cubic Corporation "DM-40 Autotape" consisting of a pair of responders located on shore and a shipboard interrogator. Using microwave transmission over a line-of-sight path, this device generates a digital output every second, which consists of the distance in tenths of meters between the interrogator and each responder. This was displayed by lights and also digitally recorded every two seconds. The baseline between the shore stations was measured from maps to an accuracy of ±10 feet and the ship's position was computed by triangulation during data reduction and printed out as Cartesian coordinates (x and y).

Temperature calibrations were performed between surveys in Lockheed Ocean Laboratory's calibration tanks. The thermistors were compared to a platinum resistance thermometer calibrated against a secondary standard which had been calibrated at the National Bureau of Standards. Calibrations were accurate to better than ±0.1°F. Time constants were measured to be 0.5 second, which is appropriate to 1 or 2 second sampling.

Two different pieces of gear were employed to obtain thermal data. The so called "profiler" consisted of a thermistor bead and a pressure transducer at the end of a conducting cable. This gear was manhandled with deliberate slowness over a large diameter sheave to record temperature versus depth profiles. The signal was conditioned for input to a x-y plotter, and it was also recorded

C. RESULTS AND DISCUSSION

An assessment of the thermal impact of the El Segundo plant on the receiving waters implies knowledge of the natural or undisturbed temperature structure. This cannot be fully known, since it is not possible to reproduce the temperature structure of Santa Monica Bay before man's impact. In this study natural temperature is defined in accordance with the Board's directive as the temperature at Benthos Station 8, located 1500 feet from the outfalls parallel to the coast in a southwesterly direction. This definition is practical and convenient since every profile set included one taken at Benthos 8.

Figure II-1 shows 12 sets of profiles taken at the station farthest from shore (RW11 in the February survey – see Figure II-A-1, Appendix II-A) on different days for more than a year. The variations in depth can be attributed to small variations in profile location about the nominal station location and to the tidal cycle. For the quarterly surveys, several profiles taken at different times are plotted together, including the most disparate. Profiles from Benthos 8 are plotted as broken lines for comparison. No profile was taken at Benthos 8 on the 27 January 1972 survey. As expected, the temperatures are generally coldest in winter and warmest in summer, yet the seasonal variation cannot be characterized in a simple way. The "sloping" profiles of May, July, August, September, and October, with a steady decrease of temperature with depth over a wide temperature range, at first seem unusual. Typical open ocean profiles have a warm surface layer, a sharp thermocline, and a uniform temperature below the thermocline, as do some of the profiles in Figure II-1. However, not enough is known about processes in Santa Monica Bay to label either type of profile as "normal." Jones (1971, p. 21) states that ". . . the most intense upwelling usually occurs in the region of the Bight during April, May, and June." The June profiles are almost vertical, so it cannot be stated that the "sloping" profiles result from upwelling.

Extra observations taken thousands of feet out during the August 1972 survey (Benson, *et al.*, 1972*b*) revealed a natural thermocline at a depth comparable to the thermocline depth observed at the profile stations. Thus, the warm surface layer nearer the outfall does not necessarily result only from the El Segundo plant discharge. There is a possible solar contribution as well, as will be discussed later.

In the quarterly reports, it was stated as an interim conclusion that the heated water rises quickly to the surface to form a layer 5-10 feet in thickness. The existence of the "sloping" profiles over a significant fraction of the year suggests that this over-simplifies the true situation. The water does rise quickly, but not necessarily all the way to the surface. In doing so, it entrains varying amounts of colder subsurface water.

During the November 1972 survey (Benson, *et al.*, 1973) large swells impinged upon the study area, mixing the water thoroughly from top to bottom. The consequent straightening of the profiles is evident in Figure II-1, which shows profiles before and after the arrival of the swell. At the same time, the temperature contours were almost non-existent; the entire thermal pattern was obliterated except directly over the outfalls. Therefore, we must conclude that large swells can be extremely effective in dispersing the heat.

Figure II-1, profiles taken at one station, supports a conclusion drawn from inspection of the profile data at all stations on the circle of 1000 foot radius: that temperatures sometimes reached 3°F, but did not reach 4°F above natural, except in a few cases during the 23-24 May survey (Benson, *et al*, 1972*a*). The conditions during this survey were exceptional in that a substantial amount of heat was apparently being added from another source to the north of El Segundo. This is especially evident in Figures II-8, II-12, and II-13 of the Second Quarter 1972 Progress Report (Benson, *et al*, 1972*a*). Excluding these exceptional cases, the reach of heated water attributable to Southern California Edison is well within the requirement for new thermal discharges that water heated 4°F above ambient shall not reach 1000 feet beyond the outfall. This requirement, however, does not apply to existing discharges such as El Segundo.

The areas enclosed by surface contours of 1°F and 4°F excess temperature (above natural) were calculated. (As mentioned previously, natural was designated as Benthos 8). Contours were sketched on the published smoothed thermal maps for values 1°F and 4°F above natural, and measured. The areas enclosed by the 4°F excess surface temperature contours were usually too small to be measured. None were larger than ten acres with the exception of one of the 23 May thermal maps (Benson, *et al*, 1972*a*, p. 30), when the area enclosed reached 15 acres. It is also evident in this map that heat is being added from an outside source.

Table II-1 lists the areas enclosed by surface contours 1°F above natural. Ebb and flood tide are distinguished. The two largest areas again were observed during the May survey when an outside heat source was contributing substantially. If these two are excluded from consideration, the areas have a median of 32.0 acres and a mean of 39.0 acres. In comparison, a circle of 1000 foot radius encloses an area of 72.4 acres. Excluding the May survey from consideration, the average area enclosed during flood tide was larger than during ebb. This may be coincidence, since there is no obvious physical reason for this occurrence.

While searching for factors affecting the thermal dispersion, correlations were sought between the variation of temperature at a profile station over 24 hours, and several other variables. From profile data, plots were prepared of temperature-depth contours, along with plant power output, air temperature, and wind speed and direction. National Weather Service Synoptic Charts for these times were also inspected. The limiting factor in this type of analysis is the number of data points in the time series for analysis. Observation of a small diurnal effect would require a number of consecutive days of data, while a small seasonal effect would require data over several consecutive years. If such regular variations existed, they were masked by the nearly random variation.

In the four quarterly surveys, there appeared to be a localized temperature increase at RW10 in the late afternoon, but in only three of the four observed instances was there a corresponding increase in plant output. This suggests some other causal relationship. The case for which there was no increase in plant output is shown in Figure II-2.

Figure II-3 shows the superposition of the 1°F above ambient (62.5°F to 63.5°F) temperature contour from each of four thermal maps taken during the February 1973 quarterly survey and listed in Table II-1. It is not possible to tell by inspection which are ebb patterns and which are flood patterns. These figures serve to emphasize the highly complex and variable nature of the thermal patterns.

The tracks followed by drogues at several depths have been presented in the quarterly reports, and those observed in February 1973 are given in Appendix II-A of this report. The observed currents were always of small magnitude, 2.5 to 20 feet per minute, with both direction and speed fluctuating greatly in time and with depth. This corresponds to other observations [e.g., Jones, J.H. (1971); City of Los Angeles (1956); University of Southern California (1955)] which characterize currents in Santa Monica Bay as being highly variable and of small magnitude. This results from a complicated mixture of tidal and wind driven effects modified by bottom topography. Such currents are not a large factor in dispersing the heat. The combination of the intake and outfall flow of roughly 50,000 cubic feet of water per minute may itself significantly contribute to the local current pattern, although no such effect was evident in the drogue tacks.

D. GENERAL CONCEPTUAL MODEL

The dynamics of the El Segundo plant outfall water and the eventual fate of the added heat is a very complicated problem. It can only be considered here in a qualitative way. Eventually, most of the heat must get into the atmosphere by radiation, evaporation, and conduction to become part of the global energy balance.

The water, initially heated about 20°F above natural, is ejected upward from about 5 feet above the seafloor in 30 feet of water. The effect at the surface is readily visible as two circular areas of small scale turbulence, 50-100 feet in diameter. The fact that considerable cold water is entrained by the rising water is evident from the diameter of the surface manifestations and from their temperatures, which may be only 5°F above natural. Harleman (1972) states that ". . . Most discharges entrain a flow at least equal to the discharge flow, often up to 10 times as much." The ejected water is dynamically active due to both its temperature and its initial velocity. Because only small currents were observed, we expect that turbulent eddy processes are responsible for the dispersion of the heat (molecular diffusion is always much smaller) in the study area (Okubo, 1970). In the ocean away from the surf zone both the scale and speed of horizontal turbulence are much greater than vertical turbulence. Presumably this rule holds in this case. Even though the "sloping" profiles may result from a fair degree of

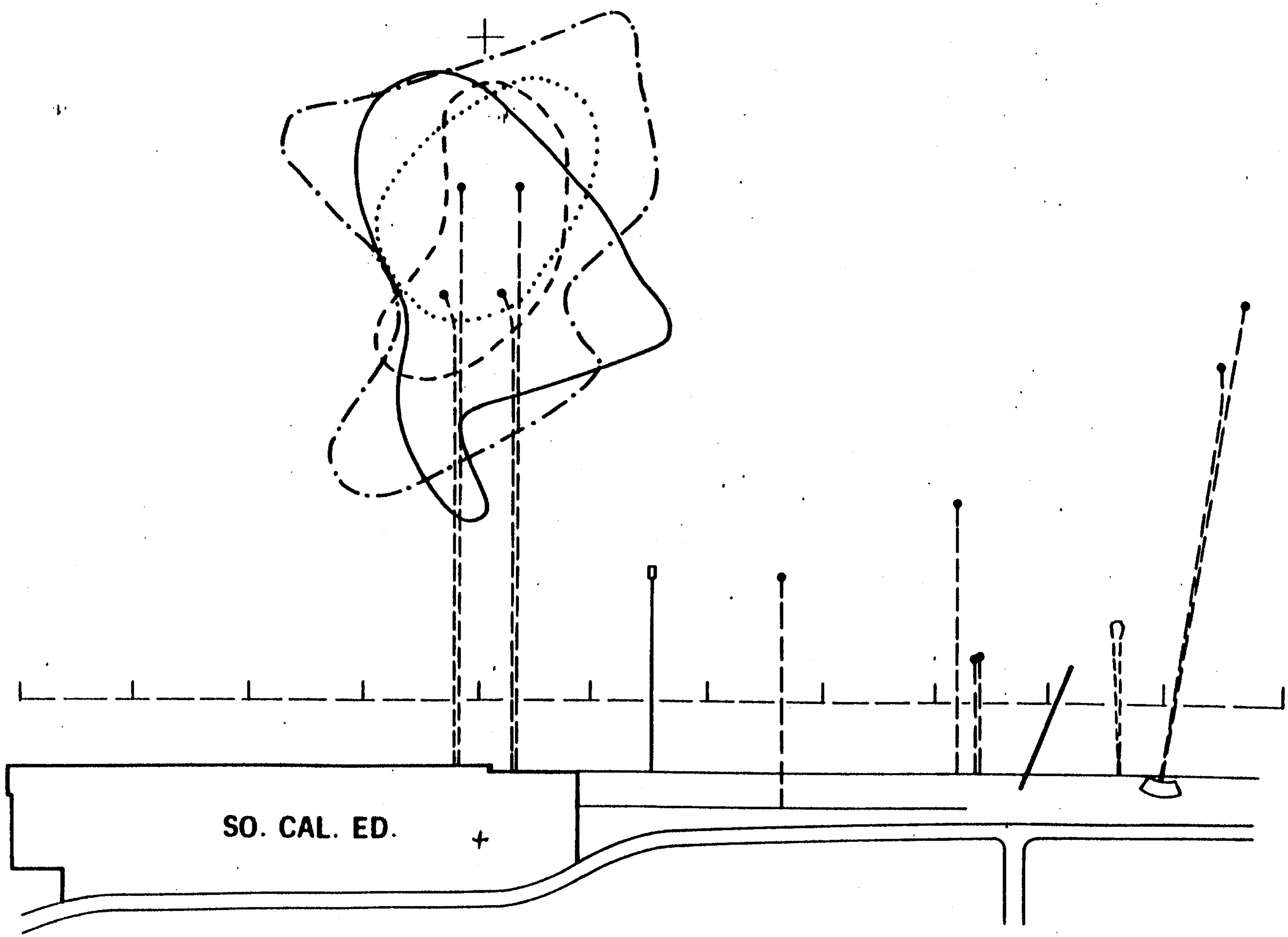

FIGURE II-3. VARIATION OF THE 1°F ABOVE NATURAL CONTOUR, FEBRUARY 7 AND 8, 1973.

III. BIOLOGICAL PHASE

A. INTRODUCTION

In conjunction with aforementioned physical surveys, Lockheed conducted four biological monitoring surveys in the receiving waters of Southern California Edison Company's El Segundo power generating station. These surveys, conducted in accordance with revised specifications set forth by the Los Angeles Regional Water Quality Control Board, consisted of a series of benthic grab, diver, trawl and intertidal surveys. This final report summarizes the results of these surveys conducted during the months of November 1971, May, August, and November 1972.

This section also briefly describes the methods utilized during the surveys and includes a brief explanation of the treatment of the data. For more specific details, reference should be made to the appropriate Quarterly Report (Benson, 1972; Benson *et al,* 1972*a*, 1972*b*, 1973).

B. METHODS AND MATERIALS

1. Benthic Survey

Nine benthic stations (Figure III-1) were sampled four times during the study. The stations were located along three transects perpendicular to the shore, 300 and 600 feet north and 1200 feet south of and parallel to the outfall lines, at the 15, 30, and 45-foot isobaths. Transect and station locations were fixed by radar, sextant triangulations and fathometer recordings from aboard the R.V. *Sea Quest.*

Three random replicate grab samples were taken at each benthic station with a Shipek Sediment Sampler (Hydroproducts). This grab covered an area of approximately 64 square inches. Immediately upon retrieval of each replicate grab sample, sediment temperature was recorded with a thermometer calibrated at six points, and measurements were made to determine the grab volume. During May, August and November 1972, temperature, salinity and depth measurements at each benthic station were also taken with a Martek Mark I Water Quality Monitor System. In November of 1972 dissolved oxygen (D.O.) was monitored with the same system. Calibration of thermistors and thermometers was performed in conjunction with those during the study's Physical Phase. Depth and conductivity probes were calibrated according to the manufacturers' recommendations.

Each replicate sample was washed with seawater through a 0.5 mm Nitex nylon sieve-cone aboard the R.V. *Sea Quest*. Organisms retained in the cone were labeled as to replicate and station location and preserved in a ten percent buffered formalin solution.

In the laboratory, organisms within a sample were sorted to major groups, then identified to the species level and enumerated. Problematic species were sent to specialists for positive identification (Appendix III-A). Taxonomic changes made during the study period are listed in Appendix III-B.

Abundance and species diversity were reported for each of the three replicate grabs at each station. Since the volume of each grab sample varied, abundances were normalized to the number of individuals of each species per unit volume (2,000 cubic centimeters) rather than per unit area as suggested in the revised specifications. From these data the mean, standard deviation, and percent occurrence for each species at each station were calculated and recorded only in the appendices of each quarterly report for comparative purposes.

Raw (non-normalized) data were statistically analyzed to reveal differences in benthic populations among and between the nine benthic stations. Statistical analyses utilized during quarterly reports included a two-way analysis of variance on station species diversity indices and the bottom temperatures. This analysis tested for differences between depths as well as between station distances from the outfall. Kendall's rank correlation was used to test the degree of correlation between bottom temperature and species diversity and a Pearson correlation analysis was run between dominant benthic invertebrates, sediment grain size, depth, and temperature. These methods are discussed in more detail under the section on Statistical Methods as are the methods employed during final analysis of the study's total benthic data.

2. Trawl Survey

Eight otter trawls per quarterly survey were conducted parallel and perpendicular to the shoreline within the study and a control area (Figure III-2). A 25-foot Marinovich semi-balloon otter trawl with a 26-foot head-rope and a 31-foot foot-rope, designed specifically for biological sampling, was used.

The net was made of the following size mesh and nylon thread netting: 1.5 inch stretch mesh No. 9 thread body, 1.25 inch stretch No. 15 thread cod end with a 0.25 inch inner liner inserted and hogtied in the cod end. 2/0 galvanized chain was hung loop-style on the foot-rope and modified with tickler chains. Trawl doors (measuring 30 X 16 inches) with 2/0 galvanized chain bridles, were rigged with 100 feet of 3/8 inch nylon rope which was shackled to a 0.25 inch hydro-wire. A cable fishing-depth ratio of 3:1, used on all trawls during the November 1971 survey, was changed to 5:1 during all subsequent surveys.

Trawling time was modified from the specified 10 minutes at 1.0 to 1.5 knots, to 5 minutes at 2 knots. Trawling time was defined to be from the time the trawl was on the bottom and trawling until retrieval was initiated. Time elapsed was monitored with a calibrated stop watch, and trawl depth was determined with a Raytheon shallow water fathometer at the beginning and end of each trawl. It was calculated that each trawl covered approximately 25,325 square feet of bottom area. To ascertain that the net was trawling properly on the bottom, the shoe runners on each door were sprayed with white paint prior to trawling and then inspected for abrasion after each trawl. Thus, trawls which did not exhibit much abrasion could be repeated.

Trawls 1 and 2 were located parallel and as close as possible to the outfall lines. Trawls 3 and 4 were conducted parallel to the shore at the depth of the outfall terminus and the 40 foot depth contour respectively, and extended equidistant on either side of the outfall terminus. Trawls 5 through 8 were conducted in a control area located 3000 yards north of the outfall study area, and followed the same configuration as Trawls 1 through 4. Trawls 5 and 6 were 200 yards apart and Trawls 7 and 8 followed the same isobaths as Trawls 3 and 4 in the study area.

During the May 1972 survey, bottom temperatures and salinites were recorded at the beginning and end of each trawl using a Martek Mark I Water Quality Monitor. In August, temperature and salinity profiles were recorded every 10 feet to the bottom, at the beginning and end of each trawl using the same sensor package. During the November 1972 survey, dissolved oxygen was monitored as well as the aforementioned parameters.

All fish, macro-invertebrates, and plant debris taken in trawls were preserved in 10 percent buffered formalin and returned to the laboratory for identification and enumeration. Fish specimens retained for the reference collection were subsequently transferred to 40 percent isopropyl alcohol.

The length, number and biomass for each fish species were determined. All fish lengths were reported as standard lengths (snout to the base of the middle caudal rays) and were measured on Wildco fish measuring boards. When anchovies were taken in large numbers subsamples of 200 individuals were utilized for size determinations. The number and biomass of macro-invertebrates were recorded, and carapace lengths of crabs were determined using vernier calipers.

Fish parasites and abnormalities were reported by species as percent occurrence. Plant debris was reported by type, trawl and biomass, as were bryozoans. Fish were arranged by rank order of abundance and percent occurrence for each trawl. A diversity index was calculated for fish, macro-invertebrates, and fish and macro-invertebrates combined. Length-frequency distributions of dominant fish were compared between control and study areas. Analytical methods employed during the quarterly and final reports are discussed in the Statistical Methods section of this report.

3. **Intertidal Survey**

Ten intertidal transects at equal distances north and south of the power plant outfall lines and perpendicular to the shoreline were sampled each survey from high water to low water. Distances from each outfall line were measured with a calibrated line and the transects labeled as follows:

1. Transect 1N – 100′ north of outfall line.
2. Transect 1S – 100′ south of outfall line.
3. Transect 2N – 300′ north of outfall line.

*DISTANCE BETWEEN ALL STATIONS IS 20 FT EXCEPT AS INDICATED IN CLOSE UP.

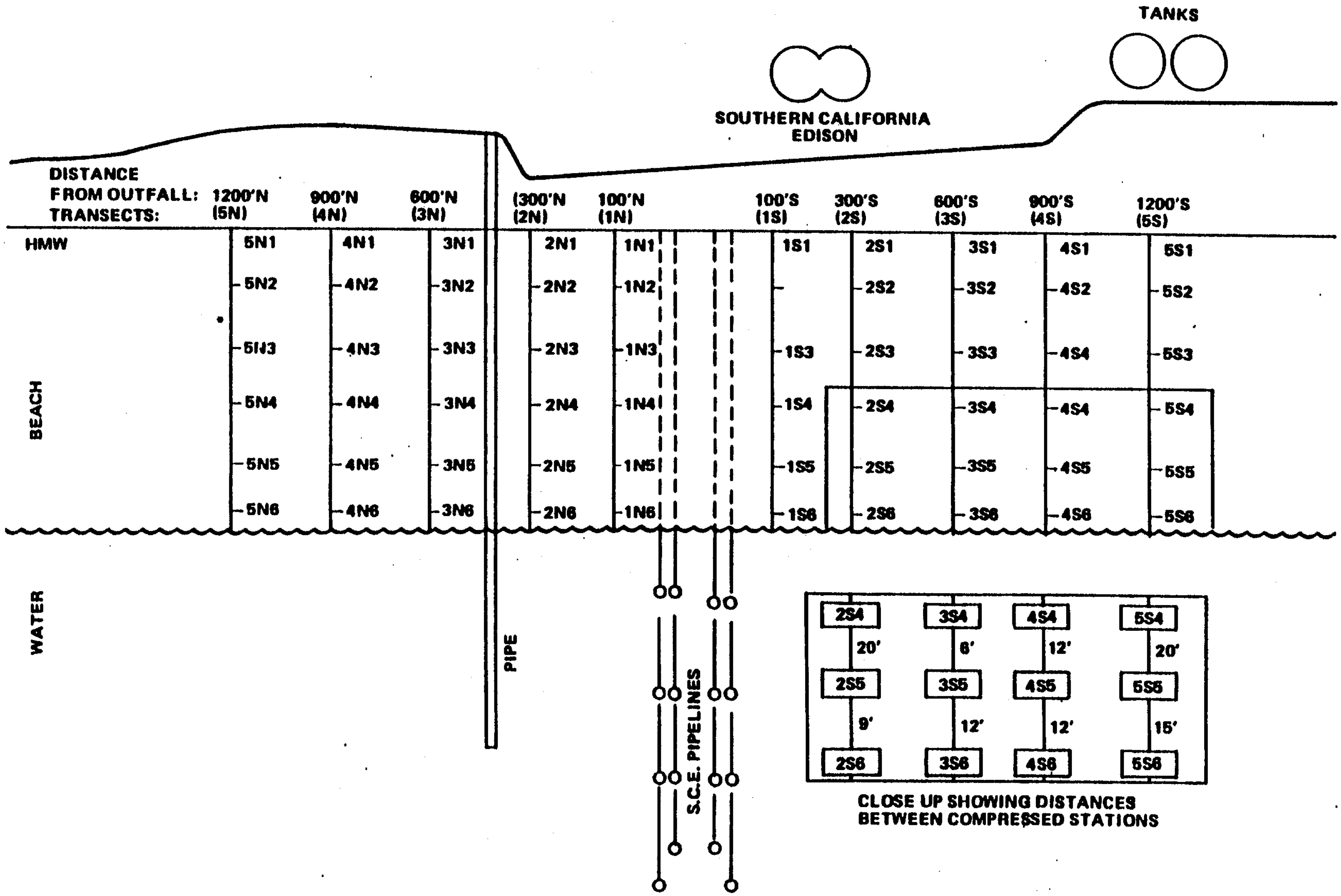

FIGURE III-3. INTERTIDAL STATION LOCATIONS – NORTH AND SOUTH OF THE S.C.E. EL SEGUNDO OUTFALL LINES less than 0.05 (one time in a twenty) of being correct. Thus we accept the alternate conclusion that differences between stations do exist, and this conclusion would have the probability of being wrong less than one time per twenty. Usually if a statement of "no difference" has a probability of 0.05 or greater of being correct, we accept it. In some cases the designation "$p<0.01$", meaning the hypothesis of no difference has been tested and rejected at the 1% level, is indicated.

a. *analysis of variance (ANOVA) and rank sum tests*

Both analysis of variance (ANOVA) and the Wilcoxon rank sum test were used to analyze for differences between two or more sets of measurements during quarterly reports. The former was used for larger, more complex samples while the latter was used for smaller samples with only two sets of measurements.

In the Wilcoxon rank sum test the data are combined and then ranked. The statistic calculated is the sum of ranks of one of the two sets of measurements. This number is then compared to a table which lists the values that this statistic would have if no difference exists between the two variables measured. One accepts or rejects this null hypothesis based on the probability associated with the calculated statistic. For more detail see Tate and Cleland (1957).

Analysis of variance does basically the same things as the Wilcoxon test. Designed for more complex situations, it enables one to test for differences in many variables at the same time (e.g., both depth and distance from the outfall). One calculates a statistic called the F ratio for each difference being tested. The value of this statistic is compared, as before, to values found in a table to find the probability of obtaining a value as large or larger than the calculated value. The details of the calculations can be found in Sokal and Rohlf (1969).

In interpreting the analysis of variance tables, "source of variation" refers to the kind of differences being tested (e.g., differences in diversity at various depths); "degrees of freedom" relates to the number of measurements involved; and "mean square" (more commonly called the variance) is the sum of squares divided by the degrees of freedom. In particular, the error mean square is simply the combined variance of the replicates at each station. In computing the F ratio for each difference being tested, one compares the mean square of each source of variation with the error mean square by taking their ratio (the F ratio). The ratio itself is not reported; instead it is stated whether the difference tested is significant or not at the 0.05 level. In the November 1971 survey, the analysis of variance for temperature was adjusted for a missing data point. This is a standard technique and is explained in Sokal and Rohlf (1969, p. 337).

During the May 1972 and subsequent quarterly surveys, a signed rank test was used to further analyze the intertidal data. This test is appropriate for comparing the medians of two groups of data when there is some basis for the pairing of observations. For example, in comparing intertidal results between the November and May surveys, diversities were paired by transect. The difference of each pair was then ranked without regard to sign. The sum of the ranks of the negative differences was compared to the sum of the ranks of the positive differences, and the smaller sum was compared with values in a probability table to test for significant differences. For more

Sorensen's index is calculated as follows:

$2j/(a+b)$, where: j = # of species occurring at both stations
a = # of species at one station
b = # of species at other station

e. Fager's recurrent species groups

Fager's Recurrent Species Group analysis was used to determine if any particular benthic or trawl species occurred together consistently at any particular station or stations. An affinity index is calculated for each pair of species (example, species a and b) encountered during the study using the following formula:

$$I = J(N_a \cdot N_b)^{1/2} - 1/2(N_b)^{1/2}$$

where:

I = Affinity Index
J = number of joint occurrences of species a and b
N_a = total number of occurrences of species a
N_b = total number of occurrences of species b

Pairs of species for which this expression was equal to or greater than 0.6 were considered to show affinity. Species which exhibited affinity were then combined into groups, and stations or areas which supported particular groups were indicated.

f. species diversity indices

There is a lack of a completely satisfactory diversity index. It has even been suggested that presently used diversity indices are completely useless (Hurlbert, 1971). Nevertheless, a species diversity index can be a useful composite statistic which is related to the ability of an environment to support a population composed of many different species present in small numbers.

The use of an index should be based upon its practical application rather than its theoretical considerations. The index used in this report is based on the Shannon-Weaver function Information Theory and is essentially a measure of the information necessary to specify an assemblage of organisms. The function, popularized in ecological studies by R. Margalef, describes the average degree of uncertainty of predicting the species to which a given individual, picked at random from a population, belongs. Uncertainty increases as the number of species increases and as individuals become more equally distributed, yielding a higher diversity index. The formula is:

$$H = -\sum_{i=1}^{S} p_i \ln p_i$$

TABLE III-1. PERCENT COMPOSITION OF MAJOR TAXONOMIC GROUPS COMPOSING THE BENTHIC COMMUNITY OFF EL SEGUNDO

Taxon	Nov. 1971	Percent Composition May 1972	Aug. 1972	Nov. 1972	Entire Survey	Rank
Foraminifera	1.23	5.43	10.82	19.59	8.33	4
Coelenterata	0.05	0.27	0.06	0.07	0.11	9
Platyhelminthes	0.29	0.63	0.03	0.15	0.28	8
Nemertea	4.17	3.80	2.10	2.41	3.23	6
Nematoda	3.36	4.83	4.69	5.38	4.45	5
Polychaeta	39.65	34.40	45.57	35.42	38.92	1
Mollusca	24.18	30.65	27.04	26.42	26.87	2
Arthropoda	25.54	17.89	8.78	7.96	16.13	3
Phoronidea	---	---	---	0.05	0.01	10
Echinodermata	1.40	2.01	0.79	2.80	1.56	7
Enteropneusta	---	---	---	0.05	0.01	11
Brachiopoda	0.02	---	0.01	---	0.01	12

were considered frequently occuring if they were collected at 40 percent or more of the total number of stations sampled during the year (Jones, 1969).

Since several species were restricted by depth, but occurred in significant numbers, the second criterion, numerical abundance, was established. Numerical abundance relates the total number of individuals of a single species to the total number of individuals of all species collected over the year. Species were considered numerically abundant if this value was 0.5 percent or greater, which included species with more than 122 individuals.

Generally, when a species was found in more than 40 percent of the stations sampled, it was also numerically abundant; only 18 of the 52 frequently occurring species were not numerically abundant. Those 34 species which were both frequent at stations and numerically abundant were considered to comprise the basic fauna in the El Segundo study area. Of these, eleven have been recorded as the most common species at Redondo Beach by M.B.C. (1972*a*, *b*, *c*; 1973*a*, and *b*). Table III-2 lists the dominant species comprising the basic benthic fauna, their numerical abundance and frequency of occurrence for each survey during the entire year.

Slight changes in numerical abundance of some dominant organisms occurred from season to season. For example, the foraminiferan, *Trochammina pacifica* showed a gradual increase in numbers from November 1971 to November 1972, while the polychaete, *Prionospio pygmaeus*, the ostracode, *Euphilomedes longiseta*, and the lamellibranch, *Tellina modesta*, showed a gradual decrease in numbers. *Armandia bioculata*, a polychaete, attained its greatest numbers in November 1971 and August 1972; a similar pattern was observed in the lamellibranch *Tresus nuttalli*. Random fluctuations in numerical abundance were recorded for the majority of the remaining species with the exception of nematode species; the polychaetes, *Tharyx* sp. and *Spiophanes bombyx*; the lamellibranch, *Macoma rexithaerus*; and the gastropods, *Acteocina inculta* and *Olivella biplicata*, whose numerical abundance remained relatively constant over the study period.

Distributional patterns with depth were evident in most of the dominant benthic invertebrates. Table III-3 lists the dominant species and the total number of individuals per species occurring at the different depths and transects over the study period. It reveals that the dominant foraminiferan species *Cribroelphidium spinatum*, *Quinqueloculina seminulum* and *Trochammina pacifica* occurred in greatest abundance at the 45-foot stations. Polychaete species exhibited a similar pattern with depth. Of 12 dominant polychaetes listed, eight occurred in greatest abundance at the 45-foot stations, while *Pectinaria californiensis* occurred in greatest abundance at the 30-foot stations. The polychaetes *Armandia bioculata* and *Prionospio pygmaeus* occurred in relatively equal numbers at all depths.

Distinct vertical zonation patterns were also evident for nematodes and nemertean species; certain species of ostracodes (*Euphilomedes longiseta*, *Parasterope* sp.); cumaceans (*Diastylopsis tenuis*); amphipods (*Synchelidium* spp.); isopods, (*Munna ubiquita*); lamellibranchs (*Tellina modesta*); and echinoderms (*Amphipholis* sp., *Lytechinus* sp.).

Definite depth zonation patterns for the cumacean, *Diastylopsis tenuis*, have also been observed by Given (1970) and Barnard (1963) along the southern California mainland shelf. Given (1970) states that this cumacean occurs in greatest abundance between 0 and 10 meters. Barnard (1963) reported similar findings for *Diastylopsis tenuis*, further substantiating the results of this study where this cumacean was recorded in greatest abundance between 0 and 10 meters. Vertical distributions for the amphipod, *Synchelidium* sp. and the isopod, *Munna ubiquita* were also similar to those reported by Barnard (1963).

It appeared that a few dominant benthic species were exhibiting distributional patterns with transect (distance from the outfall), when Table III-3 was initially examined. For example the polychaete, *Prionospio pygmaeus*; the lamellibranch, *Tellina modesta;* and the ostracode, *Euphilomedes longiseta*, were found in greatest abundance at the 1200-foot south transect, while the foraminiferan, *Trochammina pacifica*; the isopod, *Edotea sublittoralis*; and the gastropod, *Sulcoretusa xystrum* were most abundant at the 600-foot north transect. However the results of correlation analysis between species abundance and distance from the outfall disclosed that only one dominant species, *Prionospio pygmaeus*, was related to distance – its greatest numbers occurring the furthest distance (transect 1200 S) from the outfall.

ANCOVA revealed that season and depth were the major causative factors affecting the distributional patterns exhibited by many dominant benthic species. For example both these factors highly influenced the distributions of the foraminiferan, *Trochammina* and the polychaete, *Pectinaria*. In some instances season alone was the primary factor (i.e., – no interaction with depth was revealed) as was the case with the polycheate, *Nephtys* and the pycnogonids, *Oropallene* and an unidentified juvenile. It was disclosed that depth was the principal factor affecting the distributions of nemertean spp., the foraminiferan, *Cribroelphidium*, the isopod, *Munna* and the cumacean, *Diastylopsis*.

Table III-4a and 4b lists by sampling period the total number of species and species diversity at all benthic stations. A mean species diversity index for three replicates and a total species diversity (obtained by combining all species within the three replicates and then calculating the diversity) are given for each station. During the study period, total species diversity, which is a more accurate estimate of a station's diversity, ranged from 1.69 to 2.63 at the 15-foot stations, from 2.20 to 3.49 at the 30-foot stations, and from 2.89 to 3.56 at the 45-foot stations. Total mean diversities (based upon total species diversity values at each depth) and the standard deviation of these values are listed below by depth. They indicate an overall increase in diversity and a decrease in variability with depth.

STATION	MEAN SPECIES DIVERSITY	STANDARD DEVIATION
15′ Stations	2.34	0.40
30′ Stations	2.82	0.43
45′ Stations	3.21	0.19

Slightly higher species diversity values were obtained from similar depths at nearby Redondo Beach by Marine Biological Consultants (M.B.C., 1973*b*).

Species diversities were examined for variation among replicate grab samples and for the influence of depth and distance from the discharge, using a two-way analysis of variance (ANOVA) and analysis of covariance. Results of the ANOVA revealed that, despite large variation in species abundances among replicate grabs (observed throughout the study period), variation in species diversity indices among replicates was low. Furthermore, differences between diversity and depth were highly significant ($p < 0.01$) while differences between stations along the same isobath were not significant. Similar findings were revealed during analysis of covariance and correlation analysis.

These results indicate that total species diversity increased with depth, while distance from the outfall had no apparent effect on species diversity. An exception to this trend was found in the November 1972 survey, where diversity still increased with depth, but was highest at the 30-foot stations. As discussed by Benson *et al* (1973), this increase may be attributed to a more equitable distribution of dominant individuals within the grab samples at this depth.

Increases in benthic species diversity with depth were also observed by M.B.C. (1972*a*; 1973*a*; 1973*b*) at nearby Redondo Beach and by Sanders (1969) for benthic communities in Buzzards Bay, Massachusetts and Friday Harbor, Washington.

Although distinct changes in diversity were encountered with depth during this study, total benthic diversity values for each sampling period remained exceptionally constant over the

TABLE III-4b. TOTAL NUMBER OF SPECIES AND SPECIES DIVERSITY FOR THREE REPLICATE GRAB SAMPLES AT ALL BENTHIC STATIONS FOR AUGUST 1972 AND NOVEMBER 1972

Depth	600'N			300'N		1200'S	
	Number of Species		Species Diversity	Number of Species	Species Diversity	Number of Species	Species Diversity
	August 1972						
	Station 4			Station 1		Station 7	
15'	Total	34	2.63	40	2.58	47	2.54
	Mean	19	2.37	23.3	2.38	27.3	2.28
	Station 5			Station 2		Station 8	
30'	Total	36	2.51	44	2.76	57	2.65
	Mean	22	2.32	27	2.56	33.7	2.52
	Station 6			Station 3		Station 9	
45'	Total	65	3.00	80	3.30	86	3.13
	Mean	36.7	2.77	50.3	3.12	53	3.00
	November 1972						
	Station 4			Station 1		Station 7	
15'	Total	32	2.10	32	2.45	38	1.69
	Mean	16.7	1.92	17.3	2.11	19.7	1.59
	Station 5			Station 2		Station 8	
30'	Total	75	3.43	64	3.46	67	3.49
	Mean	42.7	3.10	36.7	2.85	37	3.17
	Section 6			Station 3		Station 9	
45'	Total	90	2.89	62	2.93	63	3.25
	Mean	53	2.80	40	2.87	37.3	3.04

TABLE III-5a. MATRIX OF SORENSEN'S SIMILARITY QUOTIENTS AMONG BENTHIC STATIONS FOR NOVEMBER 1971 AND MAY 1972

November 1971

Stations		15' 1	15' 4	15' 7	30' 2	30' 5	30' 8	45' 3	45' 6
15'	4	.654							
	7	.691	.609						
30'	2	.389	.547	.469					
	5	.365	.486	.426	.779				
	8	.365	.539	.441	.738	.780			
45'	3	.264	.371	.327	.606	.604	.614		
	6	.305	.410	.366	.566	.531	.590	.699	
	9	.285	.343	.294	.566	.595	.545	.730	.696

May 1972

Stations		15' 1	15' 4	15' 7	30' 2	30' 5	30' 8	45' 3	45' 6
15'	4	.592							
	7	.500	.500						
30'	2	.441	.438	.571					
	5	.395	.444	.577	.694				
	8	.461	.378	.587	.721	.750			
45'	3	.392	.285	.448	.595	.533	.590		
	6	.297	.288	.435	.600	.571	.611	.689	
	9	.383	.333	.573	.672	.643	.631	.725	.715

(Outlined areas indicate a similarity of faunal assemblages along the same isobath)

TABLE III-6. FAGER'S RECURRENT SPECIES GROUP ANALYSIS

Species	Number of Occurrences at Stations	Number of Affinities with other Species
	GROUP 1	
Nematode spp.	31	45
Acteocina cf. *inculta*	29	44
Nemertean spp.	34	42
Nephtys cornuta franciscana	27	42
Prionospio pygmaeus	36	41
Tellina modesta	36	41
Olivella biplicata	36	41
Euphilomedes longiseta	35	40
Turbonilla cf. *kelseyi*	32	40
Spiophanes bombyx	28	39
Parasterope sp. Nov.	26	39
Capitita ambiseta	21	38
Edotea sublittoralis	24	36
Macoma (rexithaerus) juv.	32	34
Anaitides williamsi	22	34
Lytechinus sp. juv.	21	33
Diastylopsis tenuis	27	32
Pectinaria californiensis	27	32
Typosyllis hyalina	23	31
Amphipholis sp. juv.	19	31
Nothria sp.	27	30
Tharyx spp.	19	28
	GROUP 2	
Chaetozone corona	20	33
Chione undatella	17	25
Trochammina pacifica	21	24
Argissa hamatipes	15	16
Volvulella cylindrica	13	14
Sulcoretusa xystrum	15	13
	GROUP 3	
Odostomia resina	29	29
Mangelia alesidota	27	21
Synchelidium spp.	26	19
	GROUP 4	
Photis lacia	18	23
Munna ubiquita	21•	22
Ophiodromus pugettensis	19	21
	GROUP 5	
Nephthys caecoides	23	8
Nerinides acuta	16	1

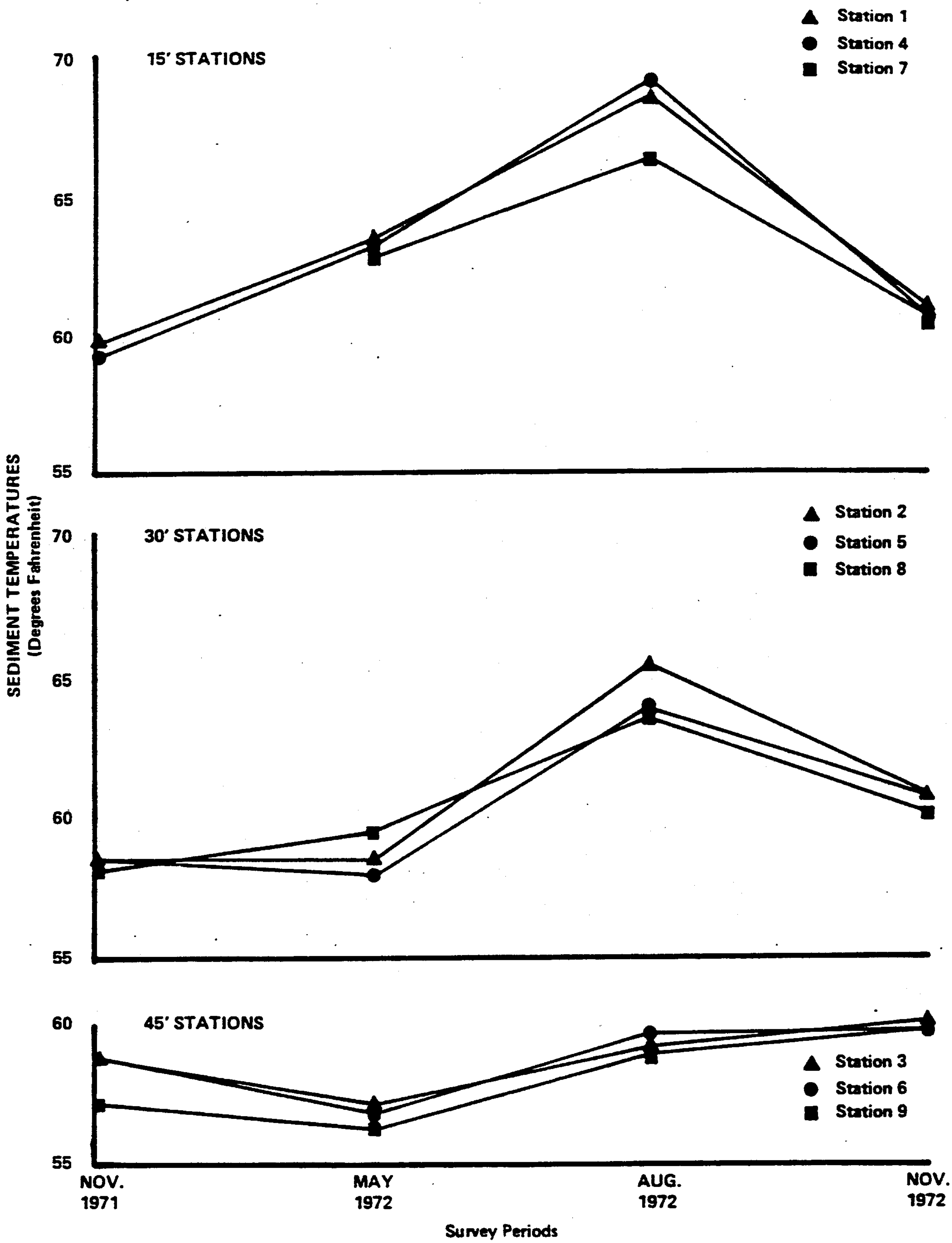

FIGURE III-5. COMPARISON OF BENTHIC SEDIMENT TEMPERATURES AT 15', 30', AND 45' STATIONS FOR EACH SAMPLING PERIOD

TABLE III-8. SUMMARY OF BENTHIC SAND GRAIN ANALYSES
(Median Values* in mm)

SAMPLING PERIOD	15' STATIONS		
	Station 4	Station 1	Station 7
Nov. 1971	0.185	0.150	0.180
May 1972	0.160	0.140	0.135
Aug. 1972	0.135	0.145	0.165
Nov. 1972	0.130	0.145	0.150
		Overall mean 0.152, S.D. 0.018	
	30' STATIONS		
	Station 5	Station 2	Station 8
Nov. 1971	0.095	0.110	0.110
May 1972	0.100	0.130	0.120
Aug. 1972	0.135	0.110	0.110
Nov. 1972	0.088	0.092	0.120
		Overall mean 0.110, S.D. 0.014	
	45' STATIONS		
	Station 6	Station 3	Station 9
Nov. 1971	0.105	0.100	0.110
May 1972	0.120	0.110	0.130
Aug. 1972	0.105	0.100	0.110
Nov. 1972	0.090	0.095	0.120
		Overall mean 0.107, S.D. 0.011	

*Median grain size values were calculated from ASTM gradation test results.

TABLE III-10. BENTHIC CORRELATION MATRIX: SPECIES VS. PHYSICAL VARIABLES
(Coefficients X 100)

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1	100	-56	61	17	31	30	32	-37	-12	-12	-11	28	-23
2	-56*	100	-40	-24	-58	-67	-78	81	37	0	0	-32	71
3	61*	-40	100	-4	26	43	39	-47	-15	-8	-3	8	-27
4	17	-24	-4	100	1	12	13	-11	-12	22	23	61	-26
5	31	-58*	26	1	100	79	54	-69	-29	4	-3	15	-34
6	30	-67*	43*	12	79*	100	68	-85	-37	12	9	30	-50
7	32	-78*	39	13	54*	68*	100	-88	-67	12	17	20	-66
8	-37	81*	-47*	-11	-69*	-85*	-88*	100	31	-7	-4	-35	66
9	-12	37	-15	-12	-29	-37	-67*	31	100	-15	-31	13	30
10	-12	0	-8	22	4	12	12	-7	-15	100	88	11	-12
11	-11	0	-3	23	-3	9	17	-4	-41	88*	100	-1	-9
12	28	-32	8	61*	15	30	20	-35	13	11	-1	100	-17
13	-23	71*	-27	-26	-34	-50	-66	66*	30	-12	-9	-17	100
+ 14	-12	53*	-15	-12	-33	-30	-50*	44*	30	-14	-15	-15	27
+ 15	-16	51*	-21	-10	-29	-28	-52	43*	32	-15	-18	-8	24
+ 16	-19	54*	-22	-11	-31	-29	-51	44*	32	-7	-14	-11	23
17	-23	13	-26	17	16	-13	-9	12	2	0	9	-1	10
+ 18	-55*	49*	-38	-6	-40	-38	-41	43*	21	9	2	-2	26
+ 19	-47*	82*	-34	-17	-43	-46	-56	61*	18	18	19	-8	64
+ 20	-45*	75*	-32	-15	-46*	-40	-53*	53*	30	10	5	4	64
21	-9	36	-15	-12	-32	-32	-46*	27	65*	-7	-15	16	42
+ 22	-30	59*	-28	-14	-42*	-39	-60*	50*	50*	-5	-13	-14	56
+ 23	-42*	67*	-32	-10	-44*	-41*	-49*	57*	11	11	9	-14	33
24	10	12	15	-5	-10	-22	-28	8	60*	8	-3	9	12
+ 25	-13	43*	-18	-9	-25	-25	-39	38	21	-6	-8	-11	23
+ 26	-43*	46*	-26	-8	-20	-29	-39	42*	9	2	12	-21	34
+ 27	17	-57*	27	-5	67*	72*	63*	-70	-36	-9	-9	26	-53
+ 28	78*	-43*	51*	8	14	17	32	-25	-24	-8	-5	21	-23
+ 29	-39	62*	-31	-11	-37	-40	-53*	49*	32	-3	-9	-7	30
30	-49*	43*	-39	-20	-36	-43	-47	46*	28	-4	-13	-20	48
+ 31	-15	-6	-8	-5	13	17	21	-21	-12	16	22	19	-26
32	-24	60*	-26	-12	-35	-36	-53	44*	41*	4	1	-4	40
+ 33	19	1	16	7	4	-12	-16	3	33	14	10	3	-16
34	-58*	66*	-36	-12	-29	-35	-44	48*	12	18	15	-7	52
35	-50*	51*	-28	-13	-14	-23	-25	31	-1	23	24	-7	38
36	20	-53*	17	69*	24	57*	47*	-50	-31	32	37	48*	-49
+ 37	-18	-8	-1	14	5	37	25	-26	-23	45*	50*	14	-39
+ 38	-43*	54*	-37	-10	-34	-38	-34	48*	-7	20	28	-1	47

+ Denotes dominant organisms
* Denotes significant correlation

TABLE III-11. BENTHIC CORRELATION VARIABLES

Variable No.	Variable
1	Temperature
2	Depth
3	Grain Size >2mm
4	Grain Size 1-2mm
5	Grain Size 0.500mm-1.0mm
6	Grain Size 0.250mm-0.500mm
7	Grain Size 0.125mm-0.250mm
8	Grain Size 0.062mm-0.125mm
9	Grain Size < 0.062mm
10	Distance from outfall (yards)
11	Distance from North transect (yards)
12	Total sample volume (cc)
13	Total Station Species Diversity
14	*Cribroelphidium spinatum*
15	*Quinqueloculina seminulum*
16	*Trochammina pacifica*
17	Flatworm spp.
18	Nemertean spp.
19	Nematod spp.
20	*Capitita ambiseta*
21	*Telepsarus costarum*
22	*Chaetozone corona*
23	*Tharyx* spp.
24	*Ophiodromus pugettensis*
25	*Lumbrineris* sp. juv.
26	*Magelona sacculata*
27	*Nephtys caecoides*
28	*Nephtys californiensis*
29	*Nephtys cornuta franciscana*
30	*Nothria* sp.
31	*Armandia bioculata*
32	*Haploscoloplos elongatus*
33	*Pectinaria californiensis*
34	*Anaitides williamsi*
35	Polynoidae unid.
36	*Nerinides acuta*
37	*Prionospio pygmaeus*
38	*Spiophanes bombyx*
39	*Typosyllis ? hyalina*
40	*Tellina modesta*
41	*Chione undatella*
42	*Macoma (rexithaerus)* juv.
43	*Tresus nuttalli*
44	*Acteocina* cf. *inculta*
45	*Mangelia alesidota*
46	*Nassarius fossatus*
47	*Odostomia resina*
48	*Olivella biplicata*
49	*Sulcoretusa xystrum*
50	*Turbonilla* cf. *kelseyi*
51	*Callipallene californiensis*
52	*Oropallene palpida*
53	*Pycnogonida* unid. juv.
54	*Euphilomedes longiseta*
55	*Parasterope* sp. nov.
56	*Edotea sublittoralis*
57	*Munna ubiquita*
58	*Argissa hamatipes*
59	*Photis lacia*
60	*Synchelidium* spp.
61	*Diastylopsis tenuis*
62	*Lamprops carinata*
63	*Lytechinus* sp. juv.
64	*Amphipholis* sp. juv.
65	*Mediomastus ? acutus*
66	*Lumbrineris tetraura*
67	Family Lumbrineridae
68	*Aricidea* nr. *fauveli*
69	*Aricidea* nr. *suecica*
70	Combined variables 68 & 69 (*Aricidea* spp.)
71	*Paraonides platybranchia*
72	*Volvulella cylindrica*
73	*Euphilomedes carcharodonta*
74	*Ancinus seticomvus*
75	*Cyclaspis* sp. B
76	*Cumella* sp.
77	*Leptocuma formansi*

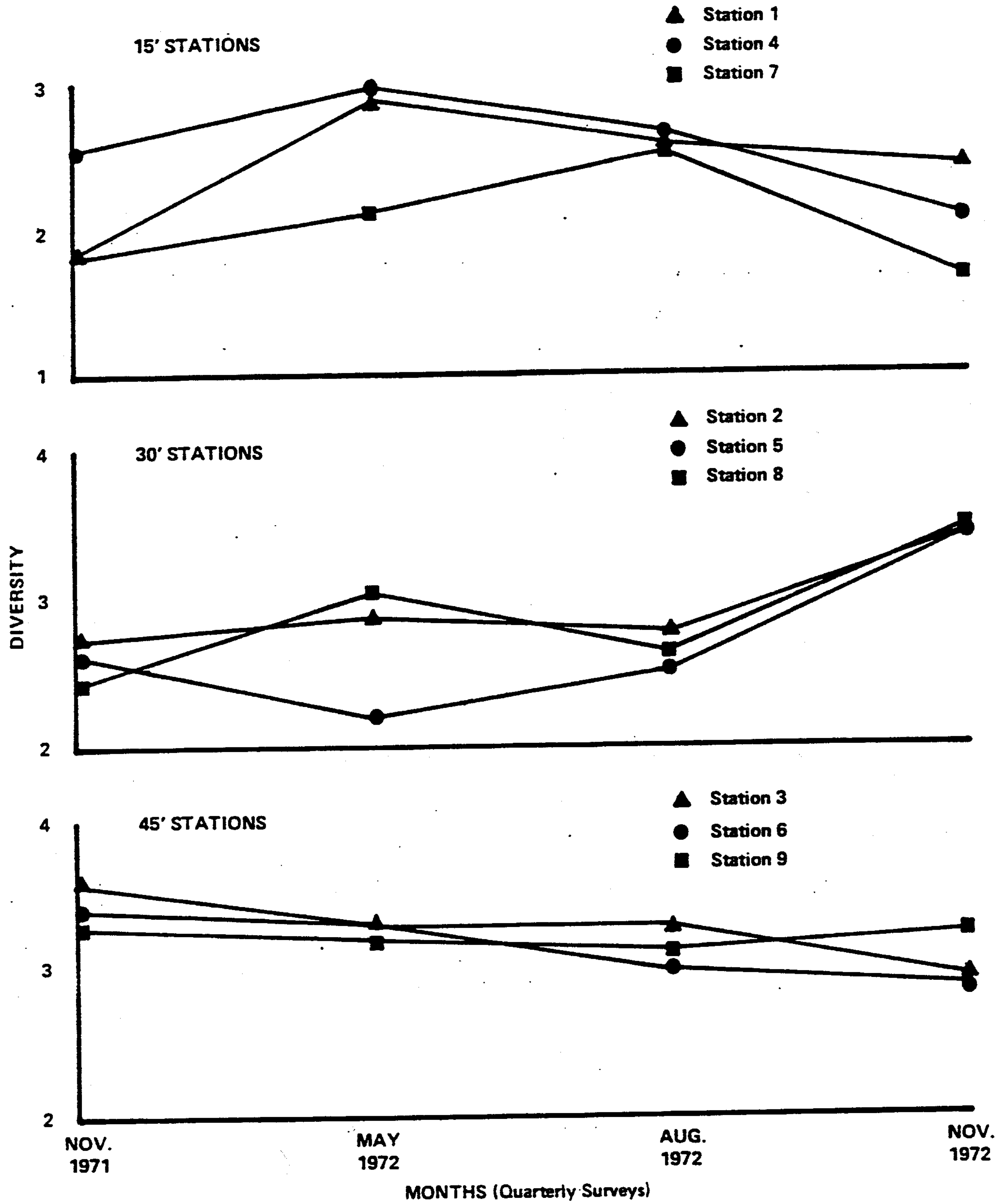

FIGURE III-6. COMPARISON OF TOTAL BENTHIC SPECIES DIVERSITY AT 15-FOOT, 30-FOOT AND 45-FOOT STATIONS FOR EACH SAMPLING PERIOD

2. Trawl Survey

A total of 12,812 fish representing 47 species and 20 families were sampled during the period of investigation. A mean of ten (S.D. = 4.6) species and 408 (S.D. = 468) individuals were taken per trawl. Although these mean values are higher than those recorded during the nearby Scattergood Plant trawl survey [Intersea Research Corporation (I.R.C.), 1973*c*], they compare favorably to mean values for near-shore fish trawled from similar habitats along the southern California coast in 1971-1972. These values (taken after I.R.C., 1973*c*), reported as mean number of fish species and individuals per trawl (± one standard deviation) and arranged by trawl area from north to south, compared to this survey's results as follows:

Trawl Area	Average # of Species/Area	Average # of Individuals/Area
Mandalay Beach	8.6 ± 3.1	52.5 ± 45.6
Ormond Beach	8.7 ± 3.8	103.6 ± 94.7
Scattergood	9.2 ± 3.9	231.0 ± 314.0
El Segundo	10.0 ± 4.6	408.0 ± 468.0
Redondo Beach	6.3 ± 3.3	232.3 ± 385.6
Los Alamitos	12.8 ± 3.8	636.4 ± 584.0
Huntington Beach	9.9 ± 4.3	216.6 ± 228.7

The distribution of fish in the study and the control areas for each sampling period is presented in Table III-12. Scientific and common names of fish are listed in Appendix III-E. A total of 25 species (7,872 individuals) were captured in the study area while 45 species of fish (4,938 individuals) were taken in the control area. For each sampling period a greater number of species was always encountered in the control area; however, the total number of individuals per sampling period was higher in the study area with the exception of the May 1972 survey, when the total number of individuals in the control area was higher.

The high standard deviations exhibited by pooled data indicate that differences between the number of species and the total number of individuals in the control and study areas should be interpreted with caution since differences could be the result of sampling error. The use of trawling to sample fish populations has been shown to be a qualitative and not a quantitative tool (Allen, *et al*, 1959; Hoese, *et al*, 1968; Roesaler, 1965). This is especially true when no replicates are taken, as was the case during the present survey. However, the consistency with which the differences between control and study areas occurred would indicate that species composition and abundances were in fact different between areas. Indeed, when the data were analyzed with a Wilcoxon signed rank test a significant difference between the control and study areas was revealed for the number of species but not for the number of individuals. However, the paucity of data casts doubt on the results of even these robust statistical tests. Although both areas are predominately flat and sandy, slight differences in habitat may account for the observed variation in species numbers as the control area appears to have more solid substrates (groins and submarine outfalls)

TABLE III-12. Continued

Family Genus species	Sampling Periods Study Nov. '71	May '72	Aug. '72	Nov. '72	Control Nov. '71	May '72	Aug. '72	Nov. '72	Totals Study	Control
Embiotocidae (cont.)										
Micrometrus minimus							1		—	1
Phanerodon atripes								9	—	9
Phanerodon furcatus	28	67	4	28	48	145	55	167	127	415
Rhacochilus toxotes					7	3	1	42	—	53
Rhacochilus vacca				1				11	1	11
Sphyraenidae										
Sphyraena argentea								3	—	3
Clinidae										
Heterostichus rostratus								3	—	3
Neoclinus uninotatus					1	1			—	2
Scorpaenidae										
Scorpaena guttata								1	—	1
Sebastes auriculatus								1	—	1
Sebastes paucispinis						3			—	3
Sebastes miniatus						3			—	3
Cottidae										
Artedius notospilotus	1				1	18	2	6	1	27
Leptocotus armatus						2			—	2
Agonidae										
Odontopyxis trispinosa					1	1	1	4	—	7
Bothidae										
Citharichthys stigmaeus	299	308	298	98	280	219	130	58	1,003	687
Paralichthys californicus	2			5	2	2		5	7	9
Pleuronectidae										
Glyptocephalus zachirus							1		—	1
Hypsopsetta guttulata	1	1	1		2			1	3	3
Parophrys vetulus		4			5	3	2		4	10
Pleuronichthys coenosus			1					4	1	4
Pleuronichthys decurrens	20	73	3		24	44	15	1	96	84
Pleuronichthys ritteri							2		—	2
Pleuronichthys verticalis	11	12	5	4	5	6	6	2	32	19
Cynoglossidae										
Symphurus atricauda				1		5	1		1	6

than the study area. A similar pattern between number of species and individuals in control and study areas was also observed during the nearby Scattergood Plant trawl survey (I.R.C. 1973*c*).

Twenty-three species of fish were captured at least once in both the study and the control areas during the entire survey. Of these only six species were found during all sampling periods in both areas. They were the northern anchovy (*Engraulis mordax*), the kelp pipefish (*Synganathus californiensis*), the shiner perch (*Cymatogaster aggregata*), the white seaperch (*Phanerodon furcatus*), the speckled sanddab (*Citharichthys stigmaeus*) and the hornyhead turbot (*Pleuronichthys verticalis*).

Table III-13 presents number of individuals, their percent occurrence, biomass, and size ranges for fish species taken in both the study and control areas during the entire survey. Total individuals, percent occurrence, biomass and size ranges are presented in Table III-14.

Only two of the 25 species trawled from the study area over the past year were never recorded in the control area. They were the shovelnose guitarfish (*Rhinobatus productus*) and the deepbody anchovy (*Anchoa compressa*). These species, represented by one individual each, were taken only during the November 1972 survey.

Twenty-two species captured in the control area over the past year were never taken in the study area. They were: *Heterodontus francisci*, the horn shark; *Triakis semifasciata*, the leopard shark; *Synodus lucioceps*, the lizard fish; *Otophidium taylori*, the spotted cusk-eel, *Paralabrax nebulifer*, the barred sand bass; *Cheilotrema saturnum*, the black croaker; *Embiotoca jacksoni*, the black perch; *Embiotoca lateralis*, the striped surfperch; *Micrometrus minimus*, the dwarf surfperch; *Phanerodon atripes*, the sharpnose seaperch; *Rhacochilus toxotes*, the rubberlip surfperch; *Syhyraena argentea*, Pacific barracuda; *Heterostichus rostratus*, giant kelpfish; *Neoclinus uninotatus*, the onespot fringehead; *Scorpaena guttata*, the California scorpionfish; *Sebastes auriculatus*, the brown rockfish; *Sebastes paucispinis*, the bocaccio; *Sebastes miniatus*, the vermilion rockfish; *Leptocottus armatus*, the staghorn sculpin; *Odontopyxis trispinosa*, the pygmy poacher; *Glyotocephalus zachirus*, the rex sole; and *Pleuronichthys ritteri*, the spotted turbot.

As was observed in the study area, most of the species exclusive to the control area were represented by few individuals ($\bar{x}$ = 4.68 individuals), with 76 percent being sampled during one quarterly survey and the remaining 24 percent occurring during only two surveys. Of those fish exclusive to the control area only the bonehead sculpin (*Artedius notospilotus*) was sampled consistently during all control area surveys; however, this fish comprised only 0.2 percent of the total catch for this area.

Nine of the total species sampled comprised 95 percent of the total catch. They were the northern anchovy (*Engraulis mordax*), the speckled sanddab (*Citharichthys stigmaeus*), the shiner perch (*Cymatogaster aggregata*), the queenfish (*Seriphus politus*), the white sea perch (*Phanerodon furcatus*), the white croaker (*Genyonemus lineatus*), the curlfin turbot (*Pleuronichthys decurrens*),

TABLE III-13. Continued

Genus species	Study				Control			
	# Individuals	% Occurrence	Biomass (grams)	Range (mm)	# Individuals	% Occurrence	Biomass (grams)	Range (mm)
Hypsopsetta guttulata	3	0.03	784	181-260	3	0.06	701	181-224
Platyrhinoidis triseriata	4	0.05	2,144	310-491	1	0.02	42	174
Paralabrax nebulifer	---	---	---	---	5	0.1	1,167	132-242
Pleuronichthys coenosus	1	0.01	264	212	4	0.08	613	153-194
Triakis semifasciata		---	---	---	3	0.06	1,578	354-550
Squalus acanthias	2	0.02	5,897	726-916	1	0.02	3,178	826
Menticirrhus undulatus	1	0.01	17	105	2	0.04	393	208-257
Syphyraena argentea		---	---	---	3	0.06	19	89-112
Heterostichus rostratus	---	---	---	---	3	0.06	30	90-105
Sebastes paucispinis	---	---	---	---	3	0.06	5	70-74
Sebastes miniatus	---	---	---	---	3	0.06	5	39-44
Leptocotus armatus	---	---	---	---	2	0.04	54	106-116
Synodus lucioceps	---	---	---	---	2	0.04	341	241-300
Otophidium taylori	---	---	---	---	2	0.04	32	151-170
Neoclinus unitotatus	---	---	---	---	2	0.04	47	92-148
Pleuronichthys ritteri	---	---	---	---	2	0.04	34	92-96
Heterodontus francisci	---	---	---	---	1	0.02	2,497	624
Rhinobatus productus	1	0.01	1,237	734	---	---	---	---
Anchoa compressa	1	0.01	19	112	---			
Micrometrus minimus	---	---	---	---	1	0.02	3	48
Scorpaena guttata	---	---	---	---	1	0.02	2	39
Sebastes auriculatus	---	---	---	---	1	0.02	163	189
Glyotocephalus zachirus	---	---	---	---	1	0.02	10	81
Totals	7,872		108,789		4,938		108,801	

TABLE III-14. Continued

Genus species	# Individuals	% Occurrence	Biomass (grams)	Size Range (mm)
Sebastes paucispinis	3	0.02	5	70-74
Sebastes miniatus	3	0.02	5	39-44
Leptocotus armatus	2	0.01	54	106-116
Synodus lucioceps	2	0.01	341	241-300
Otophidium taylori	2	0.01	32	151-170
Neoclinus unitotatus	2	0.01	47	92-148
Pleuronichthys ritteri	2	0.01	34	92-96
Heterodontus francisci	1	0.007	2,497	624
Rhinobatus productus	1	0.007	1,237	734
Anchoa compressa	1	0.007	19	112
Micrometrus minimus	1	0.007	3	48
Scorpaena guttata	1	0.007	2	39
Sebastes auriculatus	1	0.007	163	189
Glyotocephalus zachirus	1	0.007	10	81
Totals	12,811		217,590	

the walleye surfperch (*Hyperprosopon argenteum*) and the kelp pipefish (*Syngnathus californiensis*). Similar dominants were reported from trawls conducted during a corresponding time period at the Scattergood Steam Plant (I.R.C. 1973*c*), where ten species out of a total of 40 accounted for 97 percent of the total catch.

The following discussion of the nine most numerous species of fish utilizes results of the Wilcoxon signed rank test to determine if abundances of dominant species were significantly different between control and study areas. Comparisons with Scattergood trawl data (I.R.C., 1973*c*) were made when warranted. Length-frequency plots are listed in Appendix III-F.

The northern anchovy (*Engraulis mordax*) was found to be the most abundant species comprising 58 percent of the total catch. Taken during all surveys in both control and study areas, it yielded 70 percent and 41 percent, respectively, of the catch in these areas. Fifty-five percent of all the northern anchovy captured were taken in November 1971. This species was also the most abundant fish in Scattergood trawls, where 90 percent of the individuals were taken in November 1971. No significant differences were disclosed between numbers taken in the study area and those taken in the control area during the year as was the case with the Scattergood trawls. Length-frequency plots for this species (Appendix III-F, Figure III-F-1), indicate that, with the exception of November 1971, size classes in study and control areas are similar. Two distinct size classes are indicated in the November 1972 data.

croaker abundance was disclosed between the two areas. Length-frequencies (plotted in Appendix III-F), indicated a similarity in size class occurrences between study and control areas.

The curlfin sole (*Pleuronichthys decurrens*) was the seventh most abundant species, representing one percent of the total catch and also one percent of the catches in both the study and control areas. It occurred during all sampling periods in the control and study areas, with the exception of November 1972, when it was not observed in the study area. It also appeared at its highest percentage of occurrence during the May 1972 survey. Abundances were not significantly different between study and control areas. Length-frequency plots for this species (Appendix III-F, Figure III-F-7) reveal no apparent trend.

The eighth most abundant species was the walleye surfperch (*Hyperprosopon argenteum*), which constituted one percent of the total catch. Only two individuals were taken in the study area, one each November survey; while the walleye surfperch was represented in all control area surveys. Sixty-five percent of all the walleye surfperch captured in the control area were taken November 1971. Significant differences between study and control area abundances were revealed. A similar distribution was reported at Scattergood, where the walleye surfperch was never encountered in the study area. Length-frequency plots of the walleye surfperch (Appendix III-F, Figure III-F-8) revealed no trend.

The kelp pipefish (*Syngnathus californiensis*) also represented one percent of the total catch. It constituted one percent and 0.7 percent of the catches from the control and the study areas, respectively. This fish occurred during all surveys in both areas, with its greatest percentage occurrence during November surveys in the study area and August in the control area. No significant differences in abundances were revealed between the study and the control areas. Length-frequency data have not been plotted for this species.

Analysis of covariance (ANCOVA) on the nine dominant species disclosed that the abundances of five species (the northern anchovy, the speckled sanddab, the queenfish, the shiner perch, and the curlfin turbot) were affected primarily by seasonality and not depth or area (control versus study). However only the speckled sanddab and the curlfin turbot were devoid of any interaction with other factors. No relationship between the distributions of the white croaker and kelp pipefish, and seasonality, area, or depth were apparent, because of high interaction. The distributions of the white seaperch and the walleye surfperch were primarily influenced by area although interactions with other variables were also disclosed. This finding further substantiates the significant differences between these species abundances in study and control areas disclosed by the Wilcoxon test, which was corroborated by Scattergood survey results. No plausible explanation for these distributions can be offered.

The interactions revealed during ANCOVA indicate that differences in abundance between control and study areas were also dependent upon season and trawl, as well as area. The high occurrence of interaction effects is probably due to the schooling behavior of the fish being investigated. If a trawl encounters a school of a particular species of fish, the abundances for that croaker abundance was disclosed between the two areas. Length-frequencies (plotted in Appendix III-F), indicated a similarity in size class occurrences between study and control areas.

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TABLE III-15. DISTRIBUTION OF TRAWLED MACRO-INVERTEBRATES BETWEEN SAMPLING PERIODS

	Sampling Periods								Totals	
	Study				Control				Study	Control
	Nov. '71	May '72	Aug. '72	Nov. '72	Nov. '71	May '72	Aug. '72	Nov. '72		
COELENTERATA										
Class Hydrozoa										
1 *Aglaophenia* sp.	*			*	*	*		*	**	***
2 *Campanularia verticillate*	*			*				*	**	*
Plumularia alicia				*					*	
Polyorchis penicillatus						1				1
Renilla kollikeri			1		9	14	16		1	39
ARTHROPODA										
Class Malacostraca										
Order Mysidacea										
Neomysis kadiakensis				9	65	1		5	9	71
Neomysis sp.								3		3
Order Isopoda										
Munna ubiquita				2					2	
Nerocilia californica				2					2	
Pentidotea resecta							1			1
Order Decapoda										
Cancer antennarius				4				1	4	1
3 *Cancer anthonyi*	19	4		10		7	1	4	33	12
Cancer gracilis	19	44		12	6	8	11	13	75	38
Cancer sp. (juvenile)		6	1	3		5		1	10	6
Crago nigromaculata	62	21	1	24	30	14	5	45	108	94
Crangon californiensis								1		1
Heterocrypta occidentalis				1		1	1		1	2
Hippolysmata californica				1					1	
Hippolyte californiensis						6				6
Holopagurus pilosus								1		1
Lophopanopeus frontalis				1					1	
Loxorhynchus crispatus							2			2
Pachygrapsus transversus				1					1	
Pagurus ochotensis				1	3		1		1	4
Pilumnus spinohirsutus				1					1	

TABLE III-15. Continued

	Sampling Periods								Totals	
	Study				Control				Study	Control
	Nov. '71	May '72	Aug. '72	Nov. '72	Nov. '71	May '72	Aug. '72	Nov. '72		
ENCHINODERMATA										
Class Asteroidea										
Astropecten armatus		13	27	12	10	27	55	2	52	94
Pisaster brevispinus					2	3	2	10		17
PARASITES										
(Loose in Trawl)										
Hirudinea sp. A			6	3			2	3	9	5
6*Lironeca vulgaris*	123	170	138	102	256	123	97	71	533	547
Parasitic nematode					1					1
Pontobdella sp.								1		1
Total/Survey/Area	262	259	179	200	386	313	204	178	900	1081
Total Number of Species/Survey/Area	13	8	13	30	13	23	19	27		
Total Number of Species/Area									35	44

*Present

[1]Numbered footnotes -- see Appendix III-B

TABLE III-16. PARASITES OF FISH

	Study Area				Control Area			
Total Catch/Area	7,872				4,940			
Total Catch/Survey/Area	3,501	797	571	3,003	683	1,201	351	2,705
	Nov. '71	May '72	Aug. '72	Nov. '72	Nov. '71	May '72	Aug. '72	Nov. '72
Fish Species with Copepods:								
Engraulis mordax	---	---	---	52 (2%)	---	---	---	5 (1%)
Pleuronichthys coenosus	---	---	1 (100%)	---	---	---	---	---
Pleuronichthys decurrens	3 (21%)	---	---	---	10 (41%)	2 (33%)	10 (71%)	---
Pleuronichthys verticalis	---	---	4 (80%)	---	4 (100%)	3 (100%)	6 (100%)	---
Glyptocephalus zachirus	---	---	---	---	---	---	1 (100%)	---
Fish Species with Hirudinea:								
Citharichthys stigmaeus		---	1 (0.7%)	---	---	---	1 (2.6%)	---
Pleuronichthys decurrens	---	3 (10%)	---	---	---	1 (11%)	---	---
Pleuronichthys verticalis	---	---	---	---	---	---	1 (16.7%)	---
Fish Species with Ventral Cysts:								
Citharichthys stigmaeus	---	---	---	42 (42%)	---	---	---	5 (71%)
Fish Species with Isopods:								
Cymatogaster aggregata	---	---	---	---	10 (17.9%)	---	---	---
Engraulis mordax	---	---	---	---	1 (1.5%)	---	---	---
Genyonemus lineatus	2 (1.1%)	---	---	---	---	---	---	---
Hyperprosopon argenteum	---	---	---	---	2 (11.1%)	---	---	1 (2.1%)
Hypsurus caryi	---	---	---	---	---	---	---	2 (66%)
Seriphus politus	2 (1.3%)	---	---	---	1 (25%)	---	---	1 (0.2%)
Synodus lucioceps	---	---	---	---	1 (100%)	---	---	---
Total Infested/Survey/Area	7	3	6	94	29	6	19	14
Total Infested/Area	110				124			

TABLE III-18. FISH AND INVERTEBRATE BIOMASS

	Area										
	Study					Control					
	Nov. '71	May '72	Aug. '72	Nov. '72	Total	Nov. '71	May '72	Aug. '72	Nov. '72	Total
Fish*	36,590	17,777	4,223	50,199	108,789	10,790	19,994	3,817	74,200	108,801
Invertebrates**	2,510	3,865	136	1,864	8,375	842	2,119	1,575	2,620	7,156
Totals	39,100	21,642	4,359	52,063	117,164	11,632	22,124	5,392	76,820	115,968

*Values taken from quarterly reports, Tables III-13 and III-14.

**Less bryozoans and parasites.

Previously, species diversity for the quarterly trawl surveys has been calculated using a non-scaled Shannon-Weaver diversity index; however, to compare samples having varying values of S (number of species) and N (number of individuals), the scaled Shannon-Weaver index, suggested by Fager (1972), has also been utilized. Misleading results can be obtained when species diversity is used to analyze populations which may be aggregated or exhibit schooling behavior (i.e., fish). Therefore, extreme caution must be exercised in interpreting species diversity values from trawl data when assessing an area's environmental condition.

Table III-20 presents scaled (H_s) and non-scaled diversities (H_n) for fish sampled from each trawl every survey period. Total diversities for study trawls (1-4) and control trawls (5-8) are also given along with a mean diversity for each area over the entire year and a total mean value for all trawls combined.

No statistically significant difference was disclosed between study and control area diversities in November 1971, May 1972 or August 1972. However, a significant difference was revealed in November 1972 between the study (H_n = 0.656) and control (H_n = 1.494) area diversities. This was probably the result of the study area being dominated by one species, *Engraulis mordax* (2,595 individuals out of a total 3,003 for the area),and the control area having a more equitable distribution of dominant species.

Slight differences between study and control area seasonal diversity averages were disclosed by analysis of covariance. However, when variation due to temperature was removed no difference between areas was revealed, indicating that the slight difference between diversities was due to temperature variation. Since the effect was so small and temperature differences between both areas were observed to be very slight (non-significant) and completely outweighted by seasonal, depth and interaction effects, any temperature-diversity relationship is questionable. Indeed, if such a relationship was present, it was probably the result of both temperature and diversity varying with season.

Total diversity (average H_n) for the entire year was slightly higher in the control area (1.452 versus 0.813 in the study area) indicating some difference between areas. However, the calculated statistic in this case was extremely close to the cut-off value for no significant difference between areas. When scaled diversities were examined they revealed essentially no difference between areas (0.384 versus 0.506). A season to season comparison of average diversities for all trawls disclosed that May survey diversities were significantly higher than the other surveys.

No difference between fish trawl diversities in study and control areas was observed during the Scattergood survey (I.R.C.,1973) where species diversities were comparable although slightly higher than those obtained at El Segundo. Study area trawl diversities (scaled H) at Scattergood ranged from 0.116 to 0.876 versus similar trawls at El Segundo which ranged from 0.024 to 0.872. Similarly, control trawls ranged from 0.275 to 0.816 at Scattergood, while those at El Segundo ranged from 0.137 at 0.694. It is doubtful however, that these differences were significant.

SCCWRP (1973) reports dermersal fish diversity (Shannon-Weaver, non-scaled) as ranging from about 0.2-0.3 to 2.6-2.7, with either extreme occurring only rarely. Combined control and study area trawl diversities at El Segundo ranged from 0.656 to 1.863, falling well within SCCWRP's range for nearshore fish. Individual trawl diversities also remained within the range reported by SCCWRP with the exception of Trawls 3 and 4 from the study area in August 1972, which had diversities of 0.182 and 0.150, respectively. An average diversity for the Los Angeles Bight reported by SCCWRP (1973) was 1.46 which is comparable to the average diversity for combined control and study areas at El Segundo ($\bar{x}$ = 1.13).

No diversities for macro-invertebrates are reported since it was felt that the method of collection yielded insufficient data for any statistical analysis.

Trawl Summary

In summary, more species of fish were captured in the control area than in the study area; however, with the exception of the May survey, more individuals were taken in the study area. Although a statistically significant difference in the number of species per area was disclosed, no difference in the number of individuals between areas was revealed.

Two species of fish appeared to be exclusive to the study area and 22 species appeared to be exclusive to the control area. In both cases these species were represented by few specimens which were present only during a few surveys. Nine species of fish numerically dominated the entire survey, comprising 95 percent of the total catch. With the exception of the northern anchovy, *Engraulis mordax* (by far the most common fish species), most individuals of the dominant species appeared to occur in relatively equal numbers in both areas, or in greater numbers in the control area. However, only two dominant species, the white seaperch (*Phanerodon furcatus*) and the walleye surfperch (*Hyperprosopon argenteum*), exhibited statistically significant differences in abundance between study and control areas, occurring in greater numbers in the control areas.

Most dominant species were present during all surveys and occurred in greater numbers during November surveys. No apparent size class differences between study and control areas were exhibited by any dominant species. Recurrent species group analysis revealed that two basic groups of fish species frequently occurred together in both areas. With the exception of the study's eleventh ranked species, *Pleuronichthys verticalis*, these two groups were composed entirely of the nine most dominant fish.

Twelve species of macro-invertebrates appeared to be exclusive to the control area while ten appeared to be exclusive to the study area. These species, when present, were captured in very low numbers during a few surveys only, and were generally highly mobile forms. Parasitic isopods comprised 54 percent of all the invertebrates trawled. No difference between the number of study or control area fish abnormalities or incidence of parasitized fish was disclosed.

Except for the August survey, when slightly higher bottom temperatures were recorded in the control area, there were no significant differences between study and control area bottom temperatures. Slight, but non-significant, differences between area bottom temperatures were

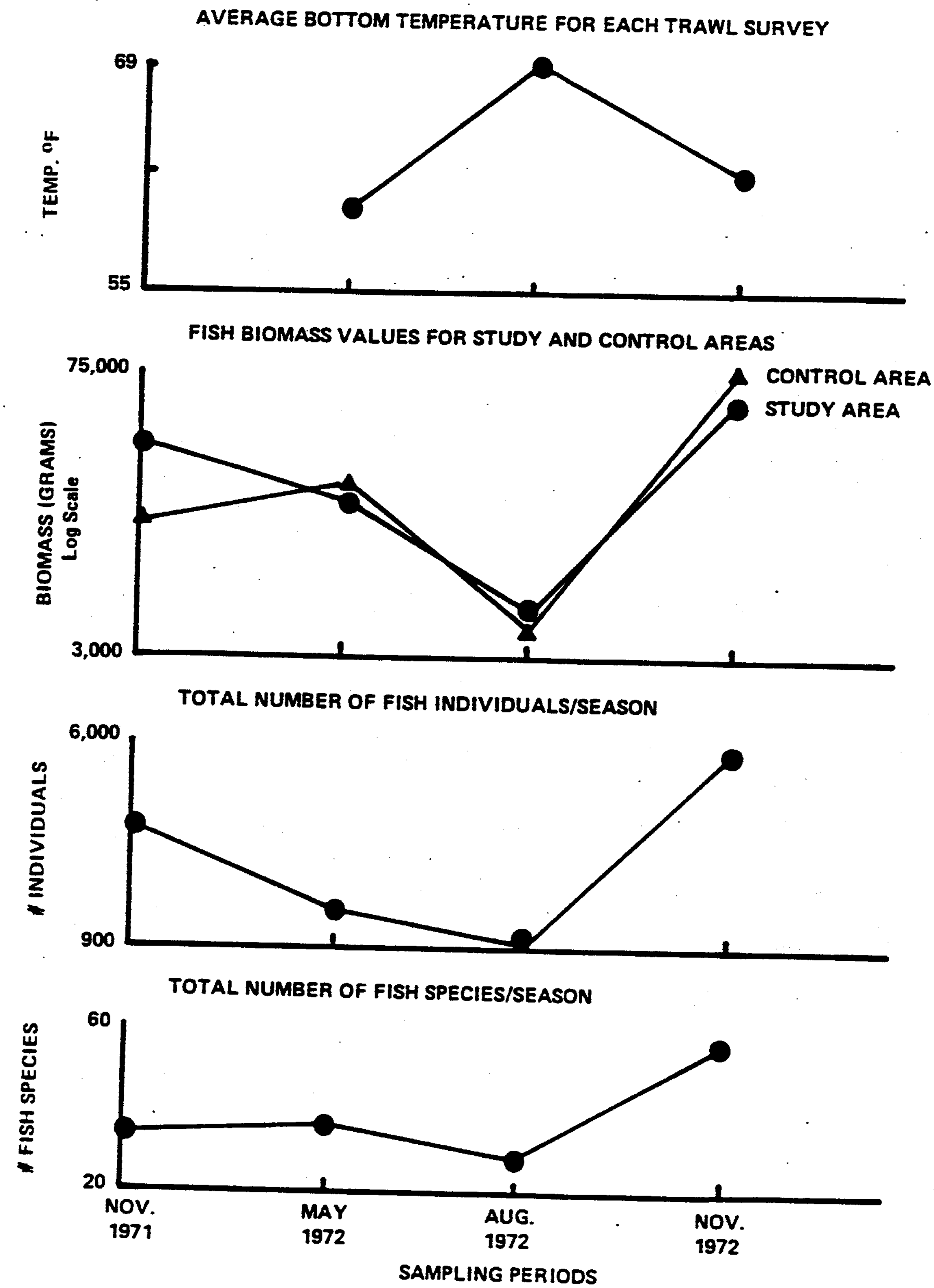

FIGURE III-7. COMPARISON OF THE AVERAGE BOTTOM TEMPERATURES, FISH BIOMASS, TOTAL NUMBER OF FISH INDIVIDUALS, AND TOTAL NUMBER OF FISH SPECIES/SEASON

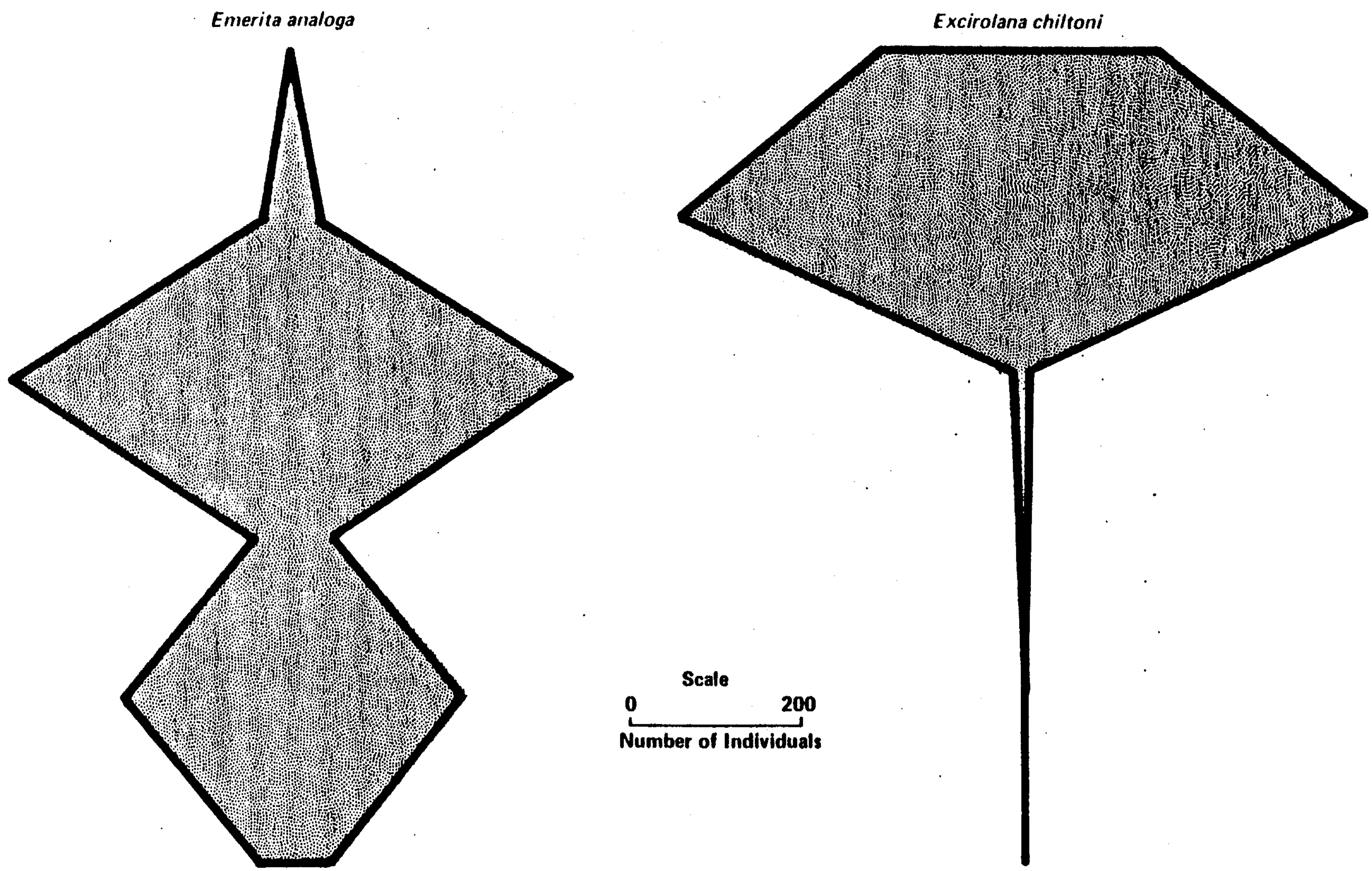

FIGURE III-8. DISTRIBUTION OF *EMERITA ANALOGA* AND *EXCIROLANA CHILTONI* IN INTERTIDAL ZONES FOR THE ENTIRE YEAR
(November 1971 to November 1972)

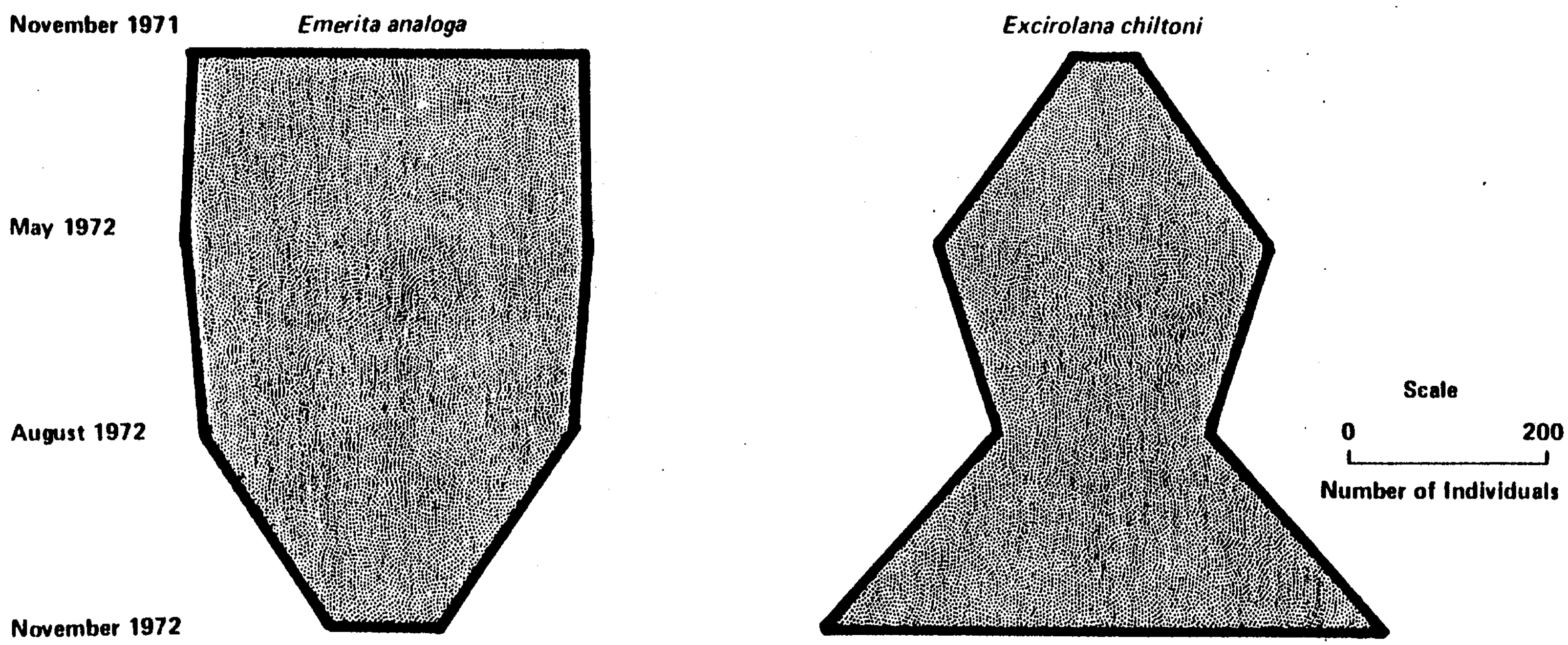

FIGURE III-9. SEASONAL ABUNDANCE OF *EMERITA ANALOGA* AND *EXCIROLANA CHILTONI*

TABLE III-22. INTERTIDAL TEMPERATURE SUMMARY FOR QUARTERLY SURVEYS

	Transects									
	North					South				
	1200′	900′	600′	300′	100′	100′	300′	600′	900′	1200′
November 1971	62.6°F (17.4°C)	62.6°F (17.4°C)	62.6°F (17.4°C)	62.6°F (17.4°C)	65.1°F (18.4°C)	64.2°F (17.9°C)	64.2°F (17.9°C)	64.2°F (17.9°C)	64.2°F (17.9°C)	63.8°F (17.7°C)
May 1972	64.0°F (17.8°C)	64.0°F (17.8°C)	64.0°F (17.8°C)	64.0°F (17.8°C)	64.0°F (17.8°C)	64.0°F (17.8°C)	64.0°F (17.8°)	64.0°F (17.8°)	64.0°F (17.8°)	64.0°F (17.8°)
August 1972	71.6°F (22.0°C)	71.6°F (22.0°C)	71.6°F (22.0°C)	71.6°F (22.0°C)	71.6°F (22.0°C)	71.6°F (22.0°C)	71.6°F (22.0°C)	71.6°F (22.0°C)	71.6°F (22.0°C)	71.6°F (22.0°C)
November 1972	63.5°F (17.5°C)	63.1°F (17.3°C)	63.0°F (17.2°C)	63.0°F (17.2°C)	63.1°F (17.3°C)	62.6°F (17.0°C)	62.6°F (17.0°C)	62.4°F (16.0°C)	62.6°F (17.0°C)	62.6°F (17.0°C)

TABLE III-23. SPECIES DIVERSITIES OF INTERTIDAL ORGANISMS AT EACH TRANSECT FOR EACH SURVEY

	North					South				
Transect	1200′	900′	600′	300′	100′	100′	300′	600′	900′	1200′
November 1971	0.308	0.692	0.293	0.692	0.320	0.324	0.00	0.536	0.744	0.690
May 1972	0.517	0.392	0.473	0.340	0.673	0.479	0.551	0.418	0.611	0.662
August 1972	0.755	0.714	0.764	0.746	0.738	0.699	0.989	0.929	0.960	0.624
November 1972	0.396	0.409	0.842	0.558	0.277	0.582	0.651	0.604	0.721	0.974

around the survey area in November 1972. Tar globules, of unknown origin, were found along the beach during the May and November 1972 surveys.

Intertidal Summary

In summary, the sand crab *Emerita analoga* and the isopod, *Excirolana chiltoni* were the most numerically abundant intertidal organisms encountered during intertidal surveys. Both species exhibited definite horizontal patterns of zonation. *Emerita* revealed its greatest abundance in the mid-tidal zone (Zone 3), and to a lesser extent in the low-tidal zone (Zone 5), while *Excirolana* was most abundant higher on the beach (Zone 2). Numerical abundance of *Emerita* and *Excirolana* fluctuated over the study period, displaying greater variability within similar seasons than between different seasons. The size-class distributions of *Emerita* also exhibited greater variability between the November surveys, than between other surveys. Analysis of covariance revealed that distance from the outfall lines did not influence abundances of either species during any survey.

Intertidal water temperatures ranged from 62.4°F in November 1972 to 71.6°F in August 1972. Results of analysis of covariance on the combined data from all quarterly surveys revealed that temperature did not differ with distance from the outfall, but did differ significantly with season, as expected.

Temperature had no influence on the abundance of *Emerita* and only a slight but non-significant influence on that of *Excirolana*. However, since virtually all variation in temperature was due to seasonality, it must be assumed that seasonality is more important in accounting for the observed difference in *Excirolana's* numerical abundance. Analysis of covariance also revealed that species diversity was not affected by either temperature or distance from the outfall.

Median sand grain size varied with both position on the beach and season, but not with distance from the outfall. No relationship between sand grain size and the distribution of the two dominant organisms was revealed.

4. Dive Survey

Thirty species of macro-invertebrates represented by 1,363 individuals were observed during the dive surveys. This total number of individuals does not include: 1) observations of *Diopatra* tubes (1,285 counts), since it was not known whether these tubes represented living or dead organisms; 2) the bryozoan *Thalamoporella* and the hydroids *Aglaophenia* and *Campanularia*, which due to their colonial nature were presented as biomass estimates; and 3) one occurrence of unidentifiable sponge fragments. Species abundances are listed by survey and depth in Table III-25. Common and scientific names of all species present during the entire year are listed in Appendix III-G.

The following six major groups of macro-invertebrates occurred consistently throughout the year during the dive surveys: coelenterates, polychaetes, decapods, gastropods, bryozoans, and echinoderms. Exclusive of the *Diopatra* tube counts, the three species represented by biomass estimates, and the sponge, the following ten species constituted 96.7 percent of the total number of individuals reported: *Olivella biplicata, Nassarius fossatus, Pagurus hirsutiusculus, Renilla*

Table III-25. Continued

SPECIES	15′ Nov/71	15′ May/72	15′ Aug/72	15′ Nov/72	30′ Nov/71	30′ May/72	30′ Aug/72	30′ Nov/72	45′ Nov/71	45′ May/72	45′ Aug/72	45′ Nov/72
Class Gastropoda (Cont.)												
Megasurcula carpenteriana											1	2
[7]*Mangelia alesidota*			1				22					
[8]*Nassarius fossatus*	1	4	7	1	19	3	59		12	8	42	4
Olivella biplicata	18	214	331	32			4				1	
Polinices lewisii			7	2	3		14	2	6	2	6	7
Polinices egg case							2					
Terebra pedroana									20	8	9	16
ECTOPROCTA												
Class Gymnolaemata												
*[9]*Thalamoporella californica*											1g	18g
ECHINODERMATA												
Class Asteroidea												
Astropecten armatus						2	9		17	64	100	39
Petalaster foliolata											1	
Pisaster brevispinus											1	2
Chordata												
Citharichthys stigmaeus	3				10-15				55-80			
Seriphus politus									5-6			

**Aglaophenia, Campanulania*, and *Thalamoprella* recorded as biomass estimates only.

[1]Numbered Footnotes – see Appendix III-B.

The most dominant characteristic of the benthic community during diving surveys at El Segundo was the presence of *Diopatra* sp. tubes. A similar dominance has been reported at Redondo Beach (M.B.C., 1973*a*). *Diopatra* was recorded 1,285 times during the year, with its greatest abundance in August 1972 and at the 30-foot isobath throughout the year.

The three species presented as biomass values occurred at 30- and 45-foot depths. *Aglaophenia* sp. comprised 76.4 percent of the total biomass recorded for the year (214 grams). *Campanularia verticillata*, 14.8 percent, and *Thalamoporella californica*, 8.8 percent.

Although 16 of the 30 species observed were present less than eight times (less than one percent of the total abundance) throughout the year, the presence of even one individual on the surface of the substrate during dive surveys can be indicative of many more individuals which are buried or inactive during the survey, and should not be construed as actual quantitative estimates of a population (Fager, 1968).

Fish were rarely observed in the dive station sampling arcs and were generally noted as extralimital observations. *Citharichthys stigmaeus* was recorded within sampling quadrats during the November 1971 and May 1972 diving surveys and *Seriphus politus* was observed within one dive station in November 1971. The following six species were observed extralimitally: *Citharichthys stigmaeus*, Embiotocid sp., Atherinid sp., *Hyperprosopon argenteum*, *Menticirrhus undulatus*, and *Paralichthys californicus*. However, these observations were so sporatic that they warrant no further discussion.

Consistent with benthic survey results, species diversity increased with depth during all 1972 surveys, with the least variability being exhibited at the 45-foot depth. Diversities were not computed for the November 1971 survey because of insufficient data due to poor diving conditions. The highest diversity values occurred in August 1972. Average diversities for each survey at each depth and an annual average for each depth are presented below:

	15 feet	30 feet	45 feet
May 1972	0.339	0.414	1.246
August 1972	0.872	1.332	1.651
November 1972	0.565	0.639	1.461
Average/Depth	0.5916	0.7950	1.453

As in the benthic survey, sediment and bottom water temperatures decreased with depth during all surveys and are listed in Table III-27. Bottom water temperatures were not recorded in November 1971. As would be expected the highest temperatures at all depths occurred during the August survey and the 45-foot stations exhibited the least variability. There appeared to be no significant difference between temperature at stations along the same isobath. Sediment temperatures at the 15- and 30-foot stations were higher in November 1972 than November 1971.

Tar was recorded at Stations 3, 4 and 9 in November 1971, Stations 4 and 7 in May 1972 and Station 1 in August 1972. No tar was observed in November 1972, possibly due to strong

Visibility was not recorded in November 1971. In May 1972 it was from 4 to 12 feet at all stations and in August 1972 from 5 to 20 feet at all stations, depending upon depth of observations. November 1972 visibilities were from 2 to 20 feet. During the year, greatest visibility occurred within 5 feet of the top of the water column, with a marked decrease between 10 and 20 feet at the deeper stations.

Dive Summary

In summary, thirty species of macro-invertebrates were observed during the dive survey, with the following taxonomic groups occurring consistently throughout the year: coelenterates, polychaetes, decapods, gastropods, bryozoans, and echinoderms.

Of the thirty species collected, ten contributed 96.7 percent to the total number of individuals reported. Five of these dominant species were also encountered in diver surveys conducted in the La Jolla Bight at depths of 16 to 30 feet (Fager, 1968). Furthermore, of the 14 genera of macro-invertebrates observed on sandy substrates at the nearby Scattergood generating station (I.R.C.,1973*c*), seven were encountered off El Segundo. Although many species at El Segundo were present less than eight times throughout the year, the presence of even one individual on the surface of the substrate during dive surveys can be indicative of many more individuals buried or inactive during the survey, and should not be construed as actual quantitative estimates of a population (Fager, 1968).

Consistent with benthic survey results, species diversities increased with depth during all surveys, with the least variability in diversity being exhibited at the 45-foot depths. Similarly, both sediment and bottom water temperatures decreased with depth during all surveys. As would be expected the highest temperatures, at all depths, occurred during the August survey, and the 45-foot stations exhibited the least temperature variability. The highest diversities occurred in August 1972.

The filamentous-oil debris encountered in the benthic survey was noted at Stations 4, 5 and 6 in November 1972 and at all stations in May and August 1972; no debris was noted in November 1972. The presence of H_2S odor in the sediment fluctuated throughout the year.

In general, substrate characteristics along isobaths remained the same throughout the year and ripple marks were oriented in a southeasterly direction during all surveys. Visibility varied with season and by depth, with the greatest visibility occurring within five feet of the water surface.

IV. COMPLIANCE WITH STATE WATER QUALITY OBJECTIVES

The California State Thermal Plan mandates that existing thermal discharges into State coastal waters meet the following requirement:

> "Elevated temperature wastes shall comply with limitations necessary to assure protection of the beneficial uses including areas of special biological significance."

"Beneficial uses" of coastal waters (nearshore zone) as outlined in the "Water Quality Control Plan, Basin 4-A, 4-B; 1973 Interim Report, California State Water Resources Control Board" include, but are not limited to, protection against degradation in the following:

Industrial Supply
Water-Contact Recreation
Commercial Fishing
Navigation
Scientific Study
Marine Habitat
Clamming and Shellfish harvesting

"Areas of special biological significance" are those areas which contain biological communities that, because of their value and/or fragility, deserve special protection against any water quality conditions other than "natural stress" which may be harmful to their existence.

This study did not reveal any degradation to the beneficial uses of coastal waters or any areas which could be considered of special biological significance. There was no evidence of the thermal field impinging upon the shoreline or bottom within the study area and no observed temperature effect attributable to the El Segundo station, upon any measured biotic parameter. It was therefore concluded that the El Segundo Generating Station is in compliance with California State Water Quality Objectives.

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APPENDIX II-A

First Quarter 1973 Progress Report
Southern California Edison Company
Thermal Effect Study, El Segundo
Power Generating Station, Physical Phase

Current drogue tracks shown in Figure II-A-32, confirm the usual observation that the area's currents are of small magnitude and highly variable with depth and time. Figure II-A-33 shows wind speed and direction measured at nearby Los Angeles International Airport, and also the high and low tides, connected by straight line segments for clarity. Figure II-A-34 is of air temperature and dew point and Figure II-A-35 shows incoming solar radiation intensity, all measured at the airport.

Interim Summary Conclusions

1. During the February survey the undisturbed or bottom water was approximately 60°F.
2. As observed during previous surveys, the heated water rises quickly to the surface to form a layer 5 to 10 feet in thickness. Extra profiles taken farther out revealed the existence of a natural thermocline at a depth of 10 to 20 feet.
3. Earlier reports have concluded that the current pattern within the study area is highly variable and always of small magnitude. Evidence from this report supports this conclusion.

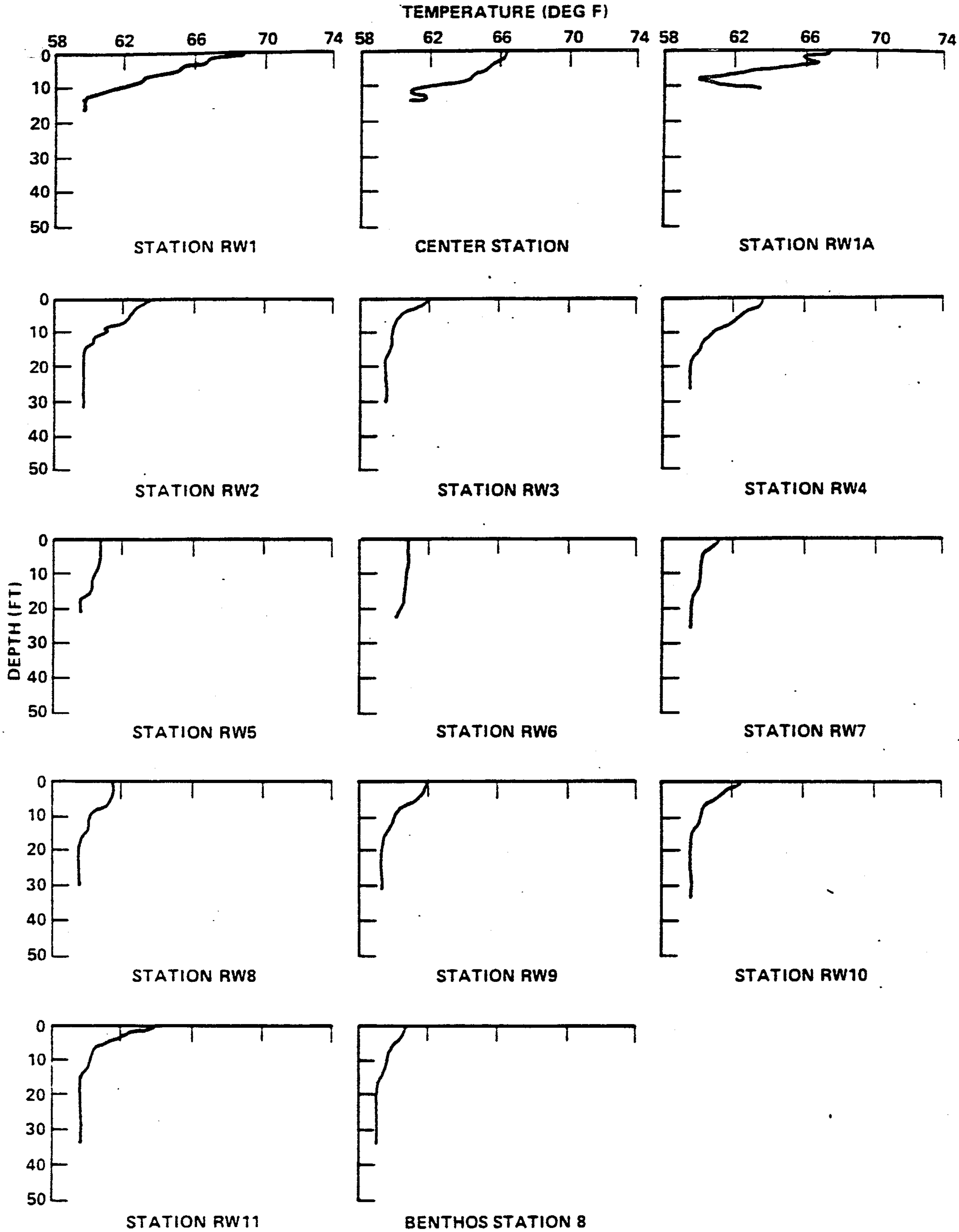

FIGURE II-A-2. PROFILES, 1614-1641, 7 FEB 1973

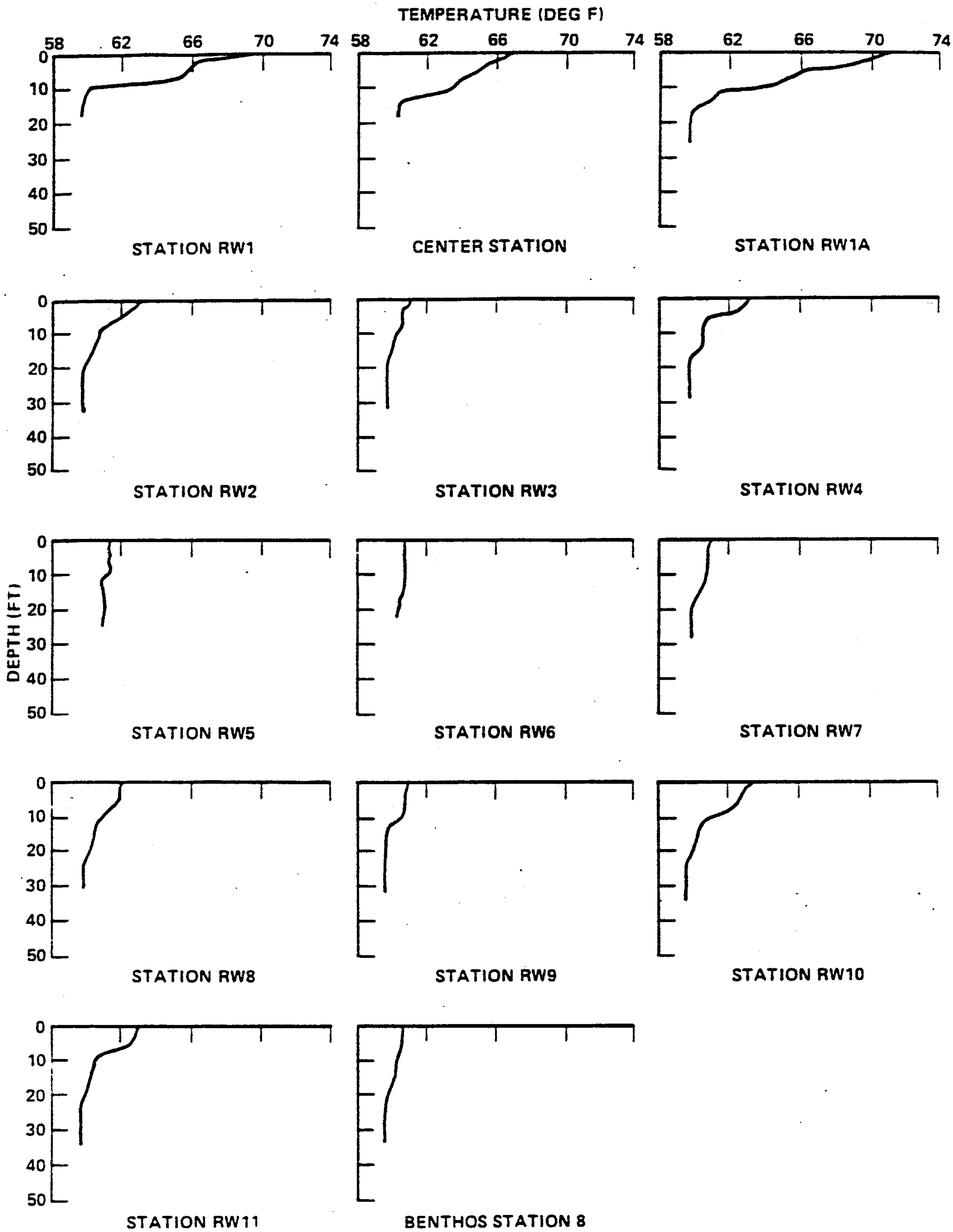

FIGURE II-A-4. PROFILES, 1855-1930, 7 FEB 1973

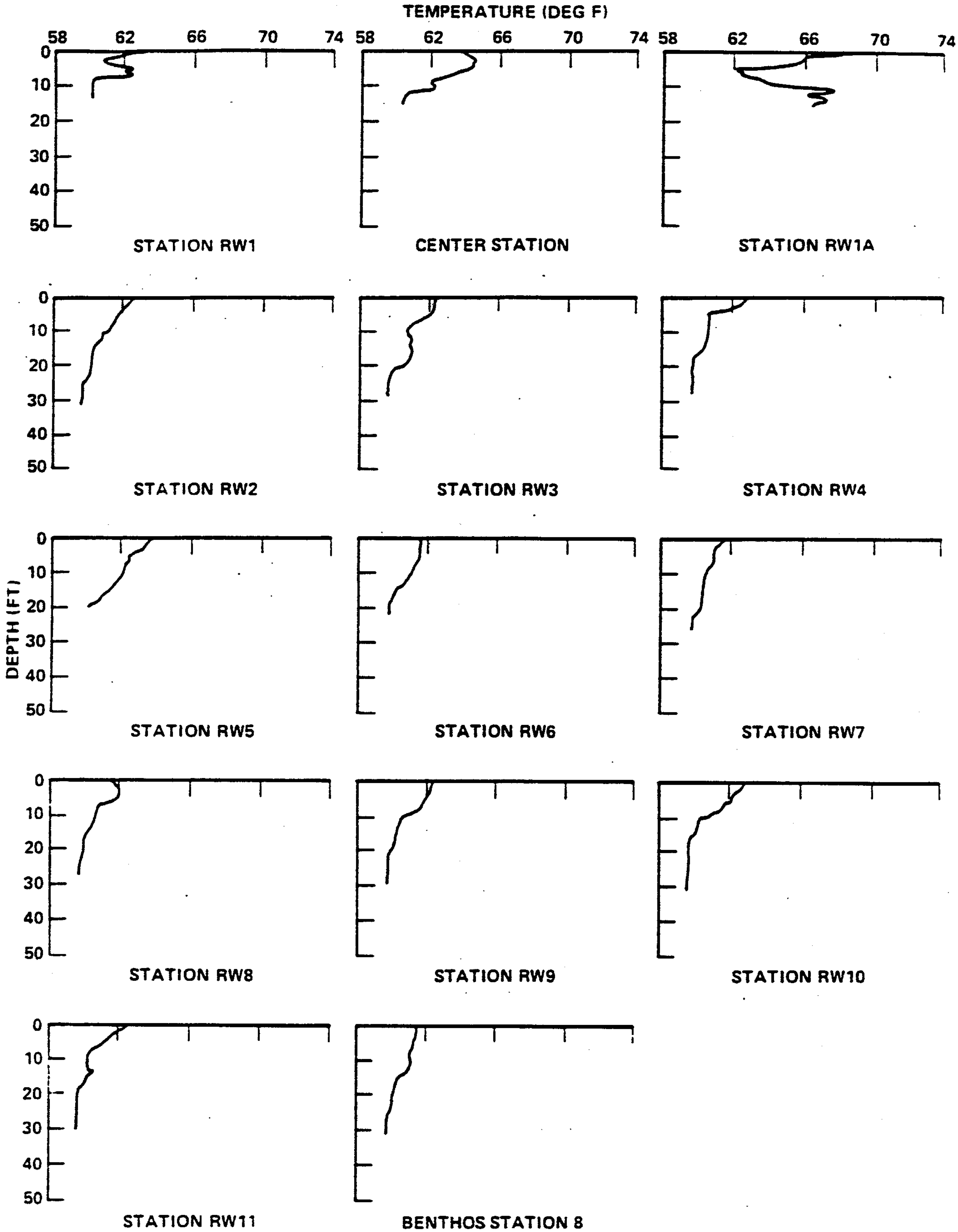

FIGURE II-A-6. PROFILES, 2306-2333, 7 FEB 1973

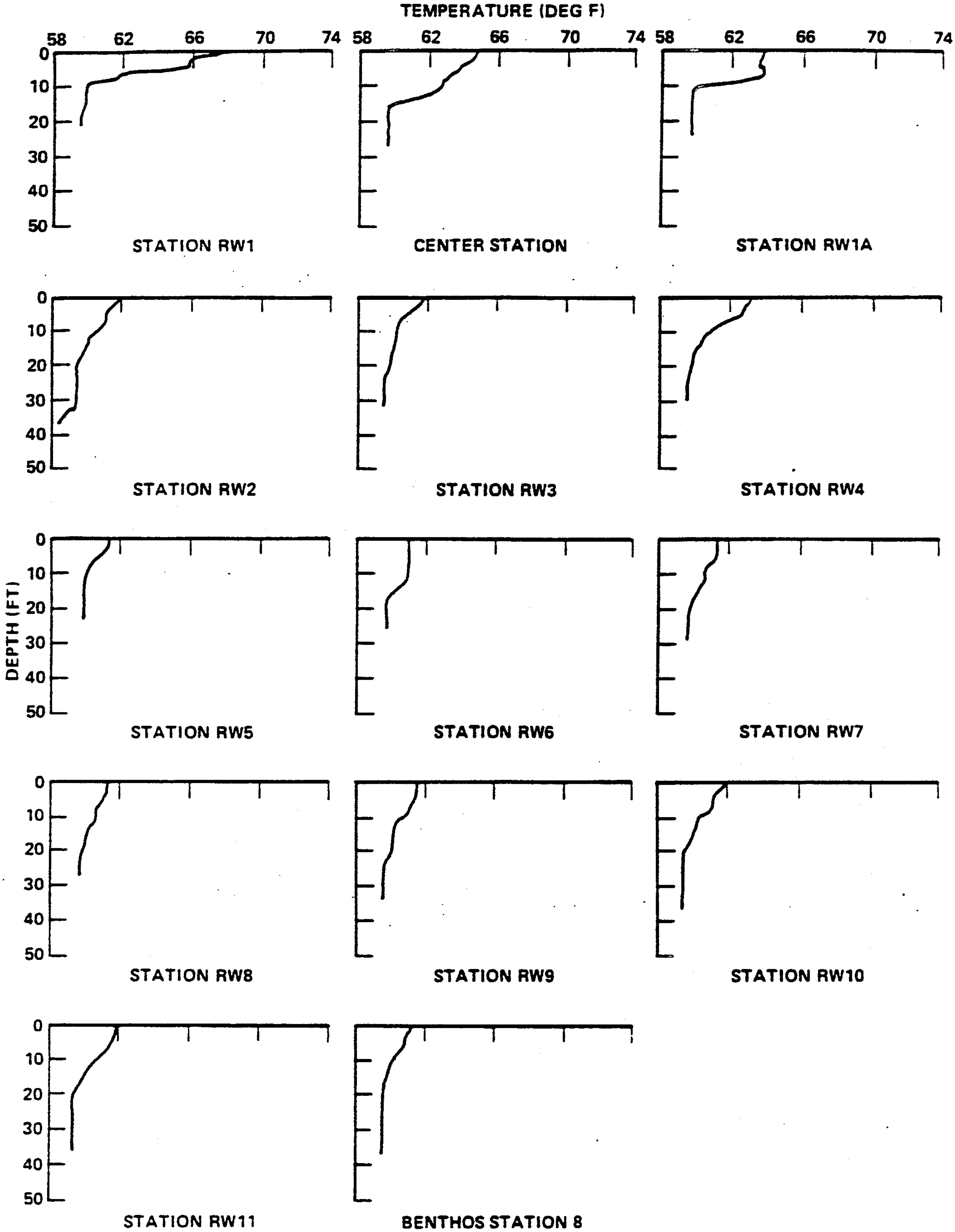

FIGURE II-A-8. PROFILES, 0412-0444, 8 FEB 1973

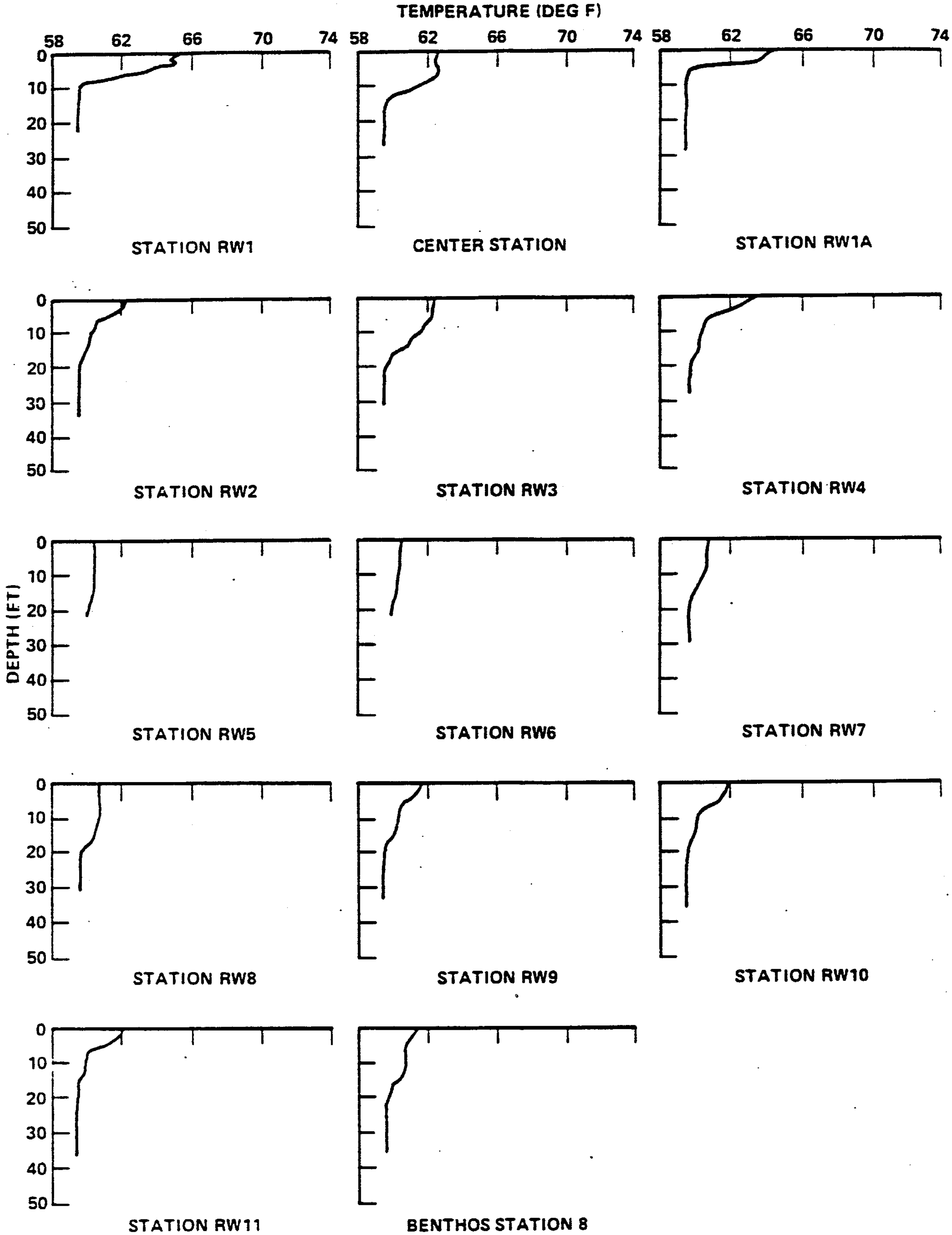

FIGURE II-A-10. PROFILES, 0720-0801, 8 FEB 1973

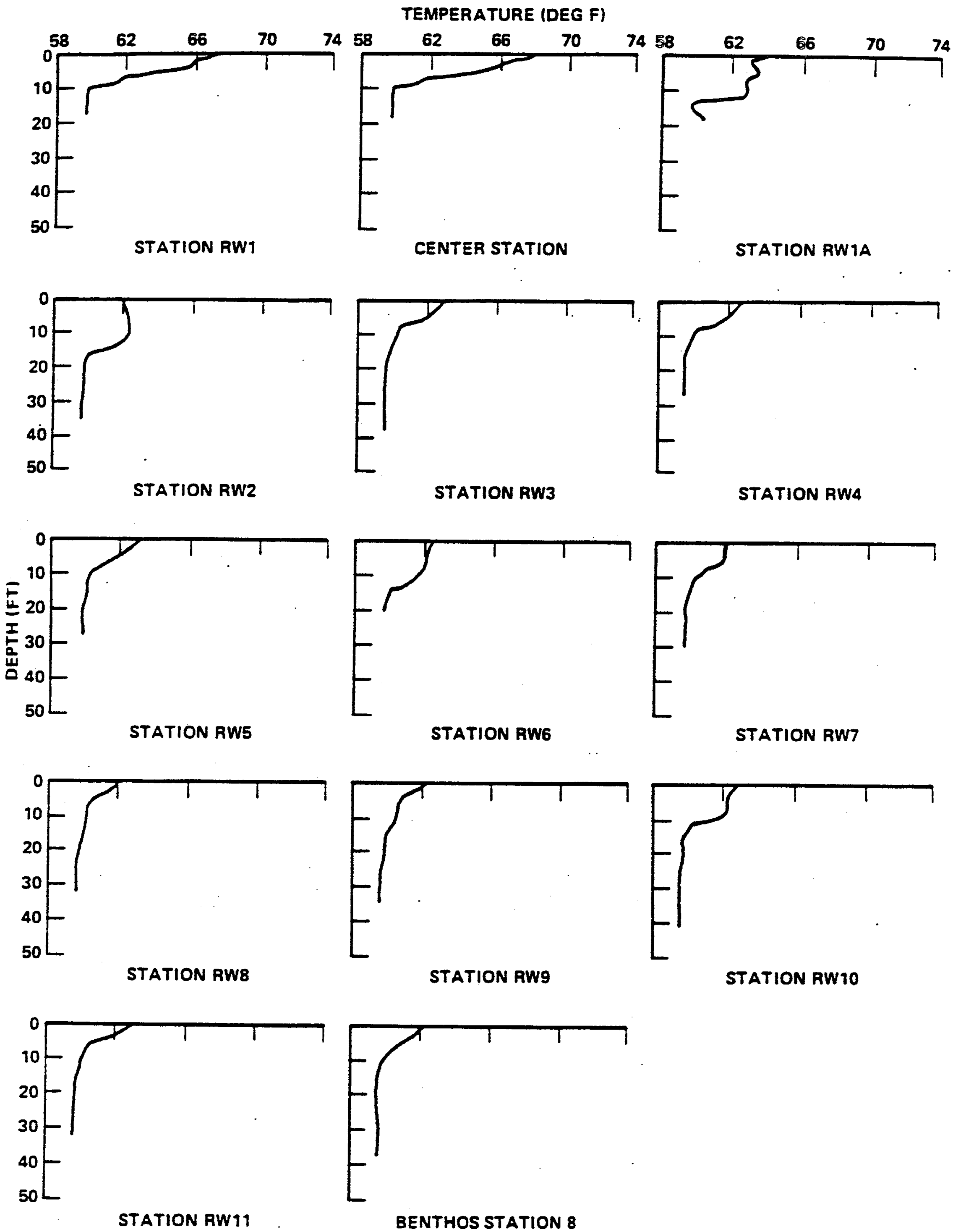

FIGURE II-A-12. PROFILES, 1105-1138, 8 FEB 1973

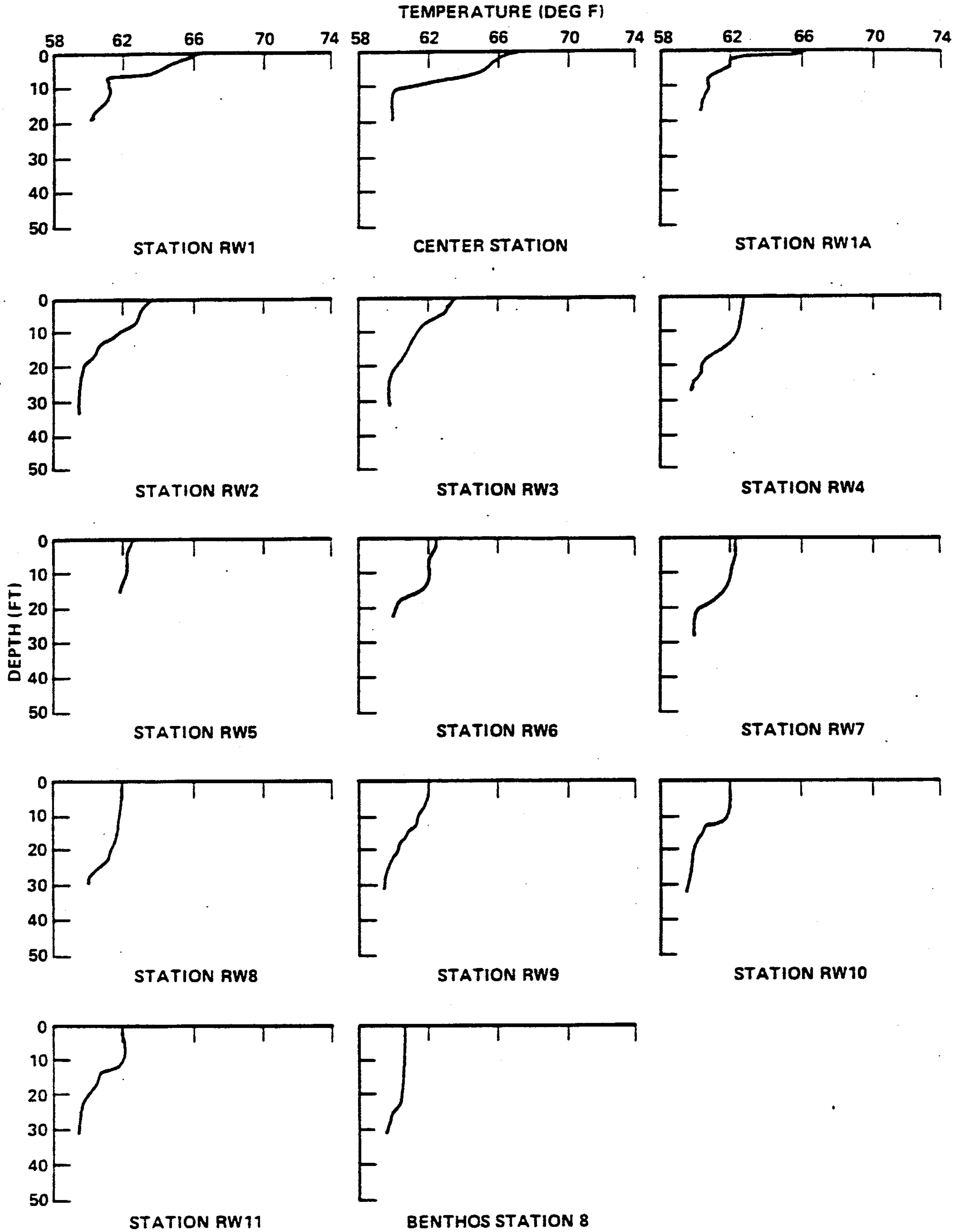

FIGURE II-A-14. PROFILES, 1503-1540, 8 FEB 1973

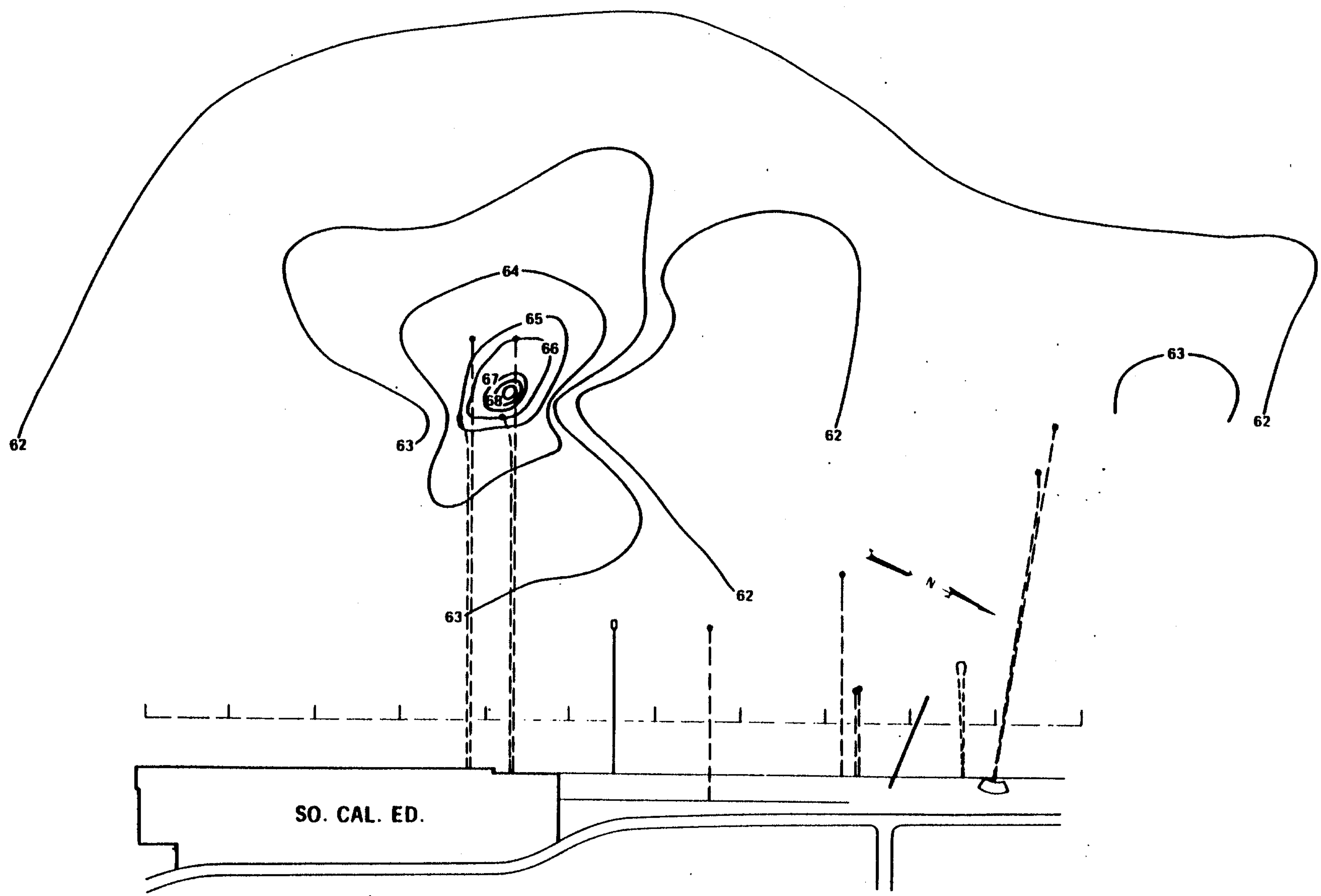

FIGURE II-A-16. THERMAL PATTERN, 18 INCH DEPTH, 1937-2055

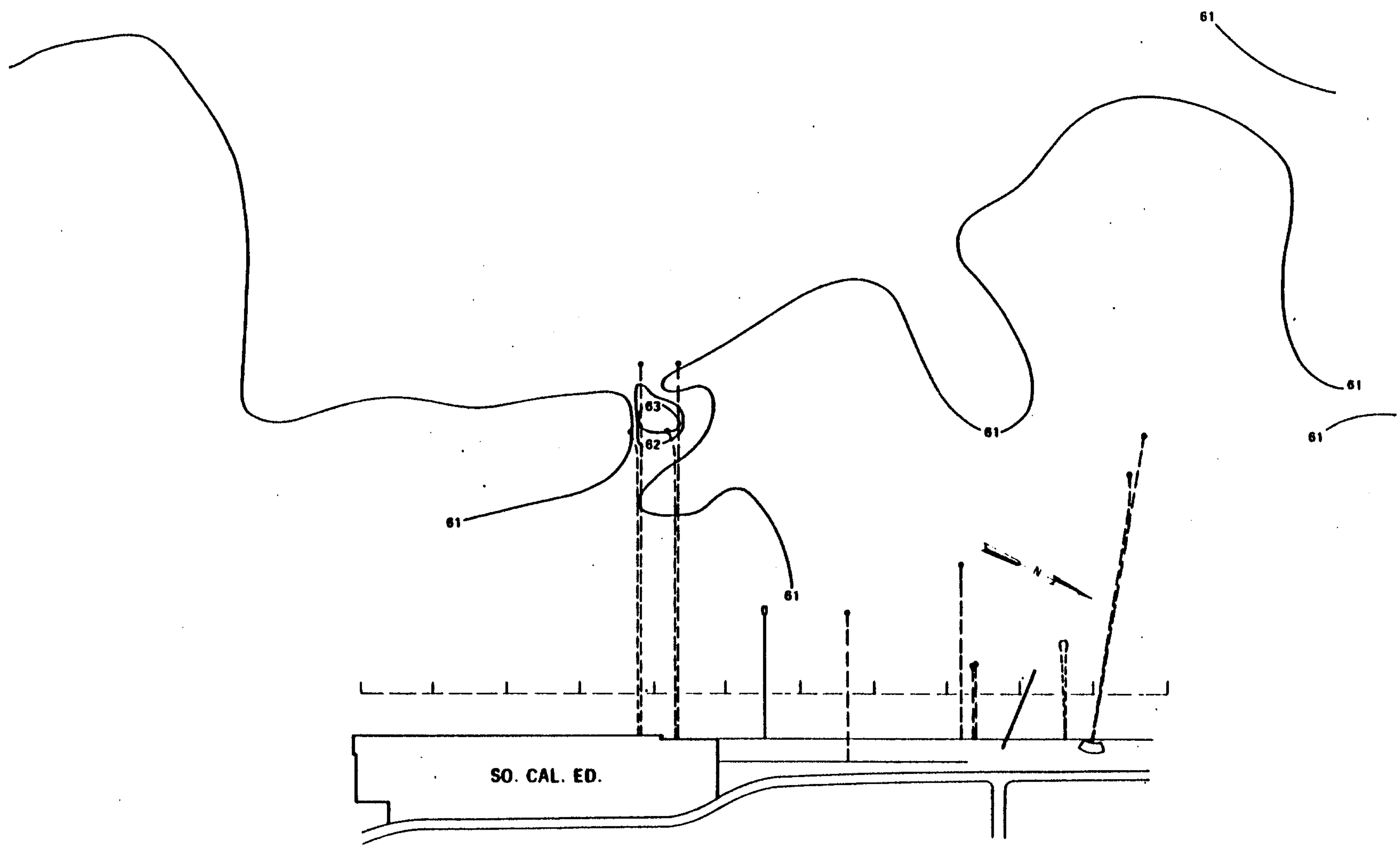

FIGURE II-A-18. THERMAL PATTERN, 14 FOOT DEPTH, 1937-2055

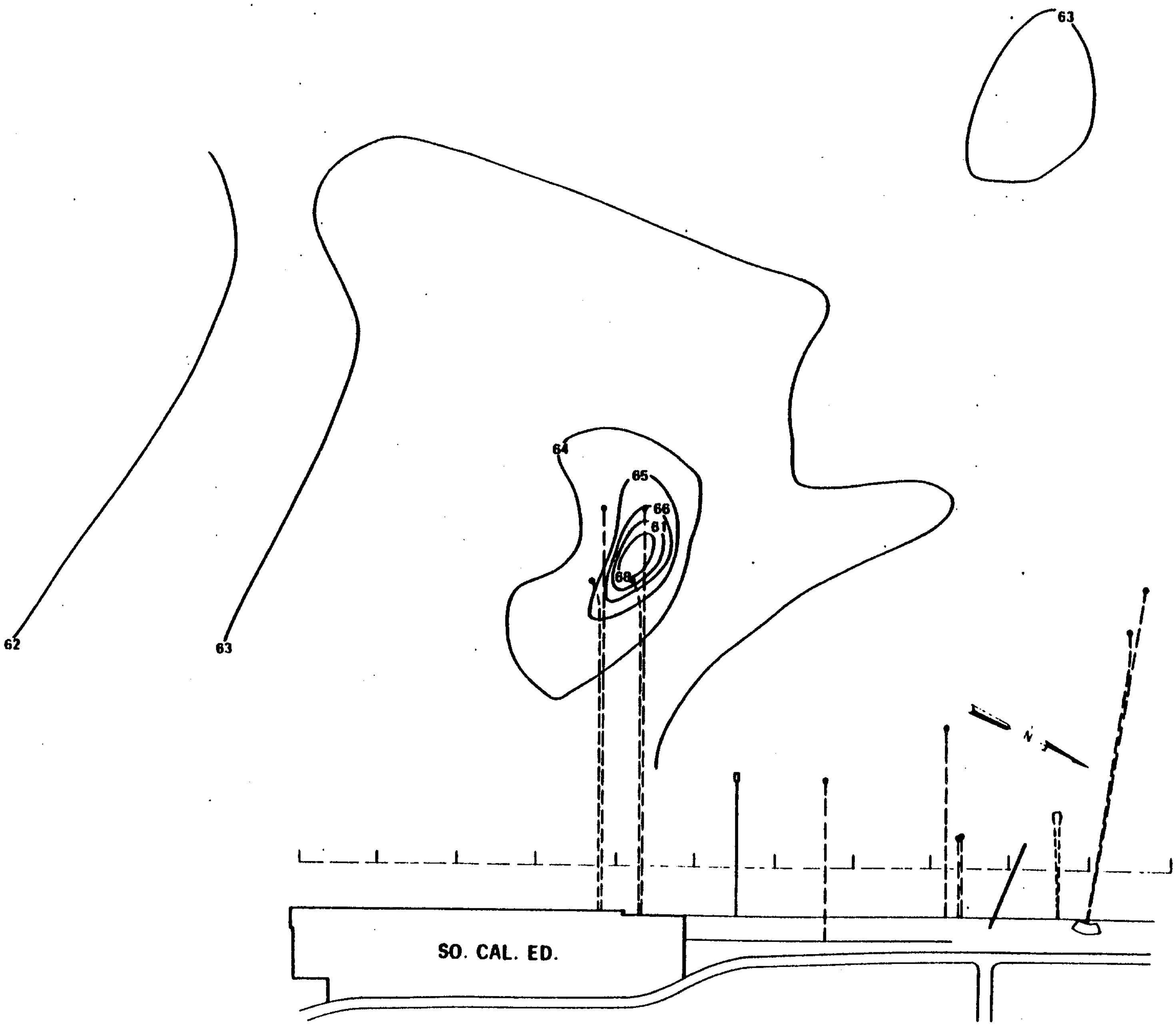

FIGURE II-A-20. THERMAL PATTERN, 18 INCH DEPTH, 0224-0404

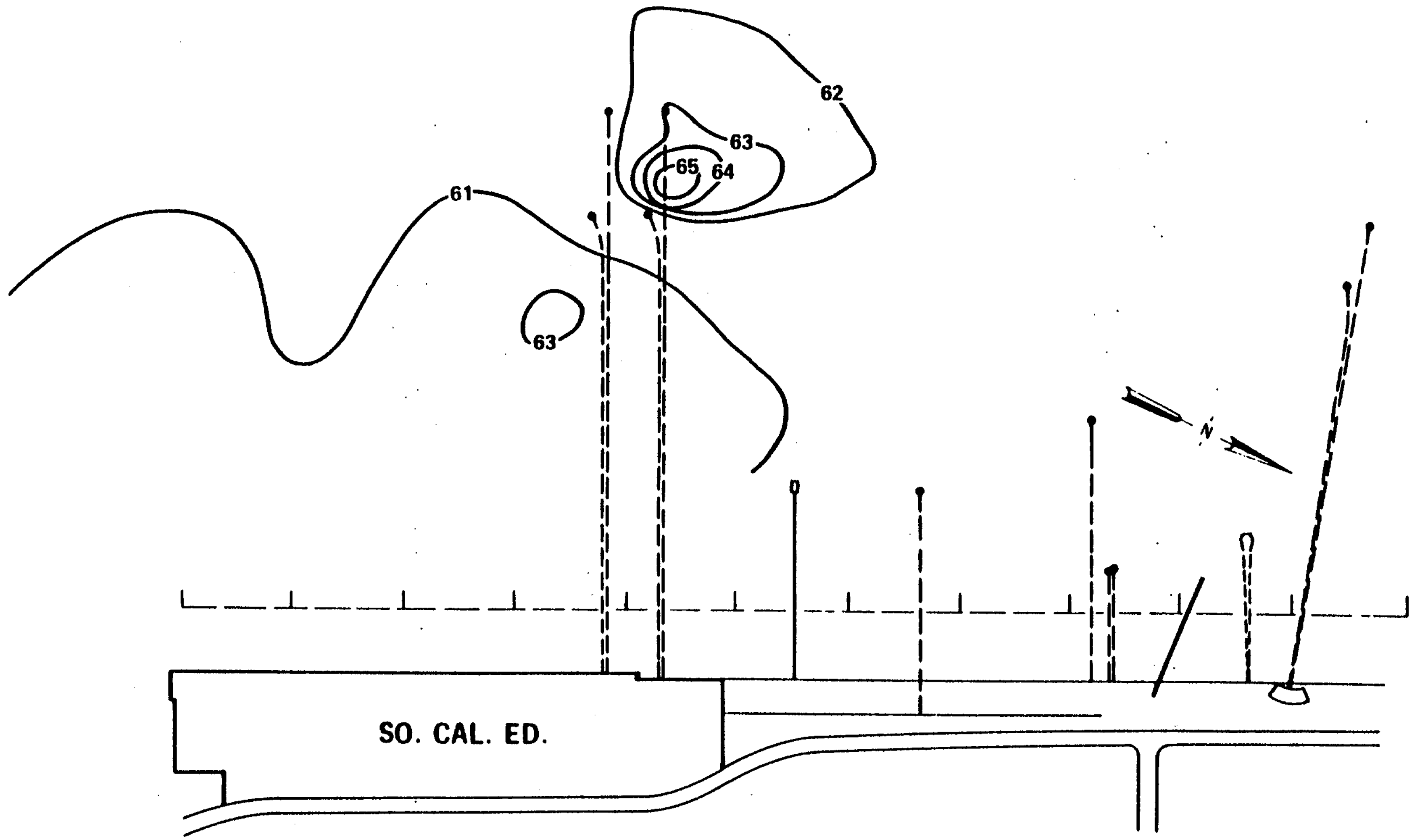

FIGURE II-A-22. THERMAL PATTERN, 14 FOOT DEPTH, 0224-0404

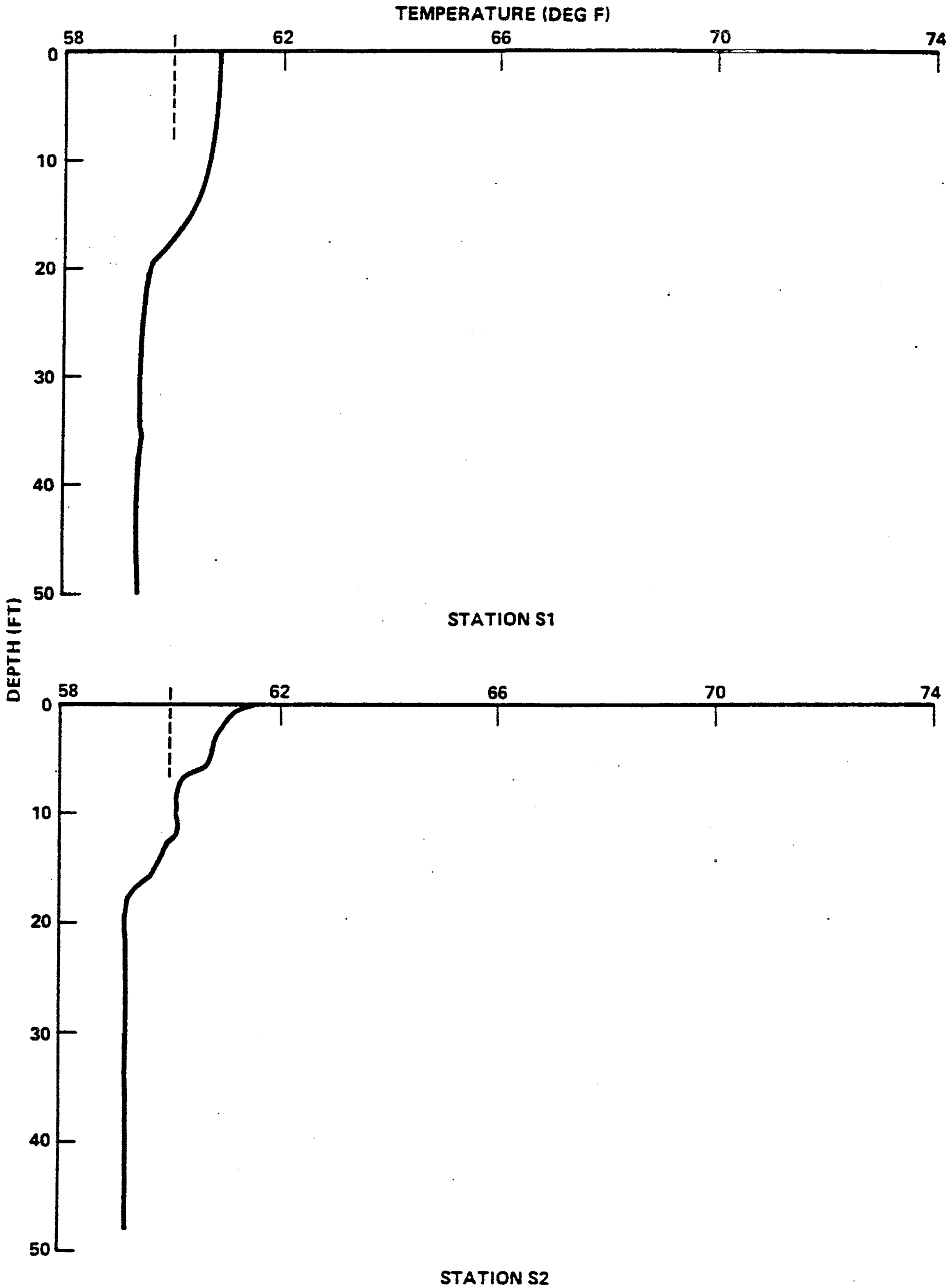

FIGURE II-24. SPECIAL PROFILES TAKEN AT S1 AND S2

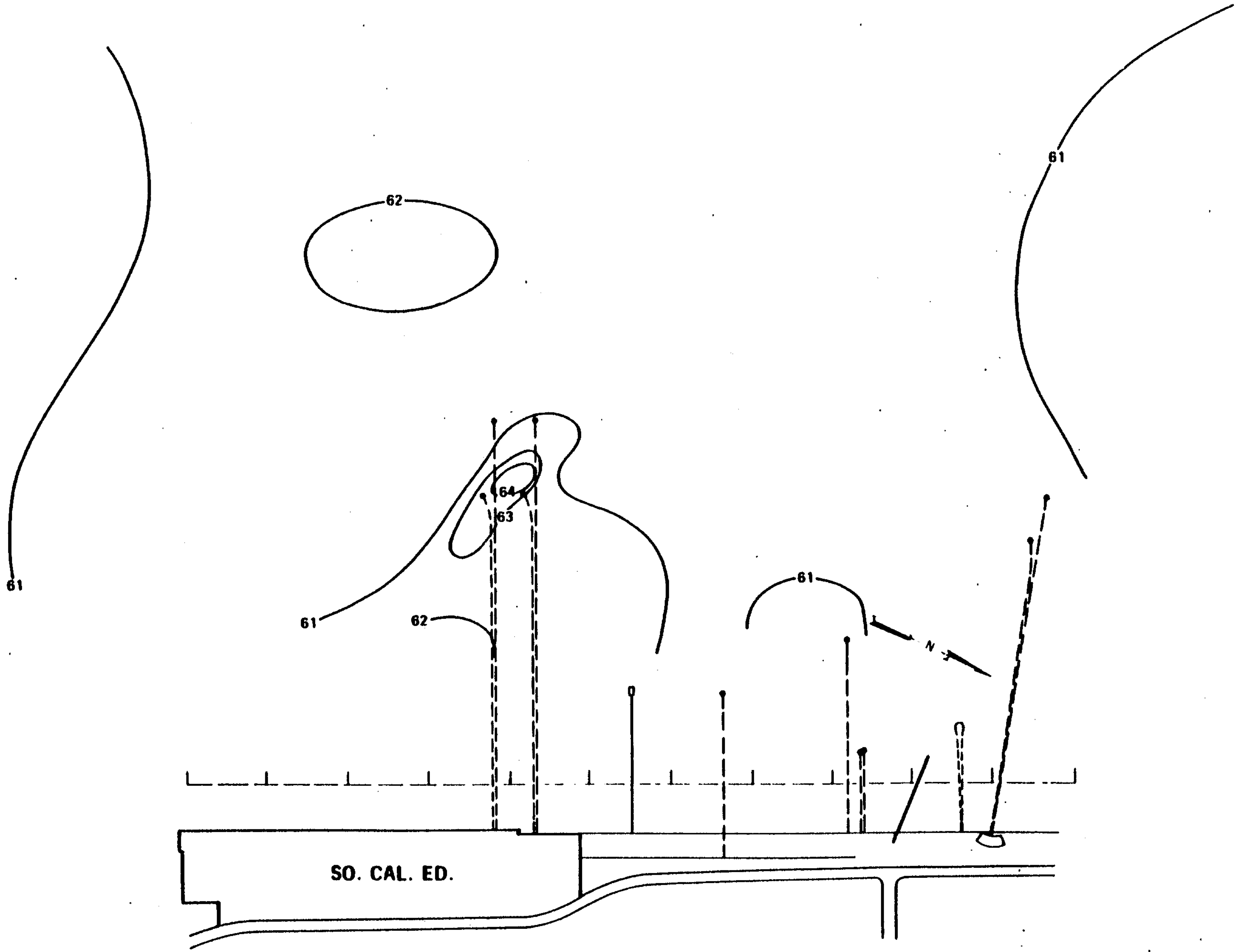

FIGURE II-A-26. THERMAL PATTERN, 7 FOOT DEPTH, 0825-1010

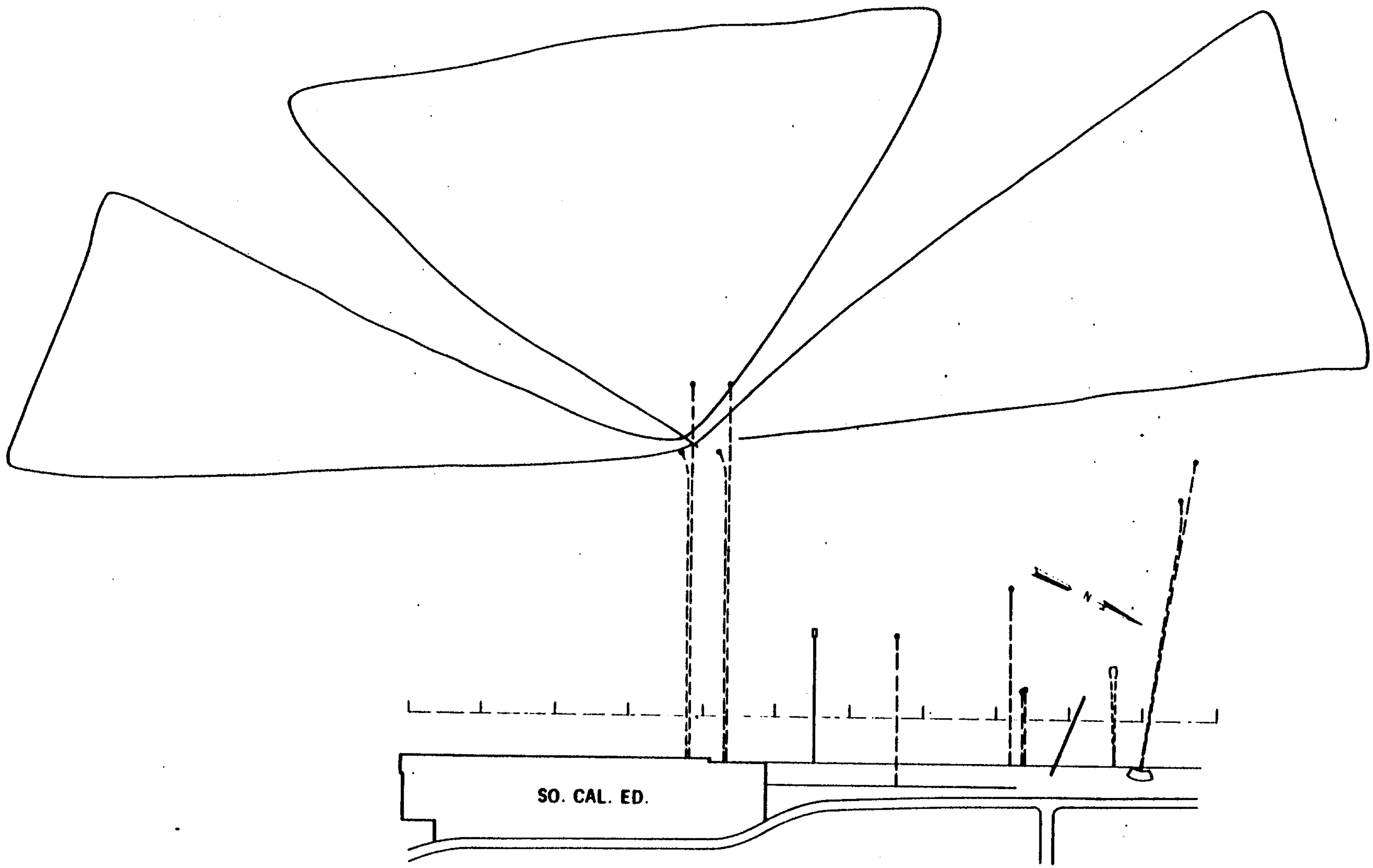

FIGURE II-A-28. SHIP TRACK, 1254-1405, 8 FEB 73

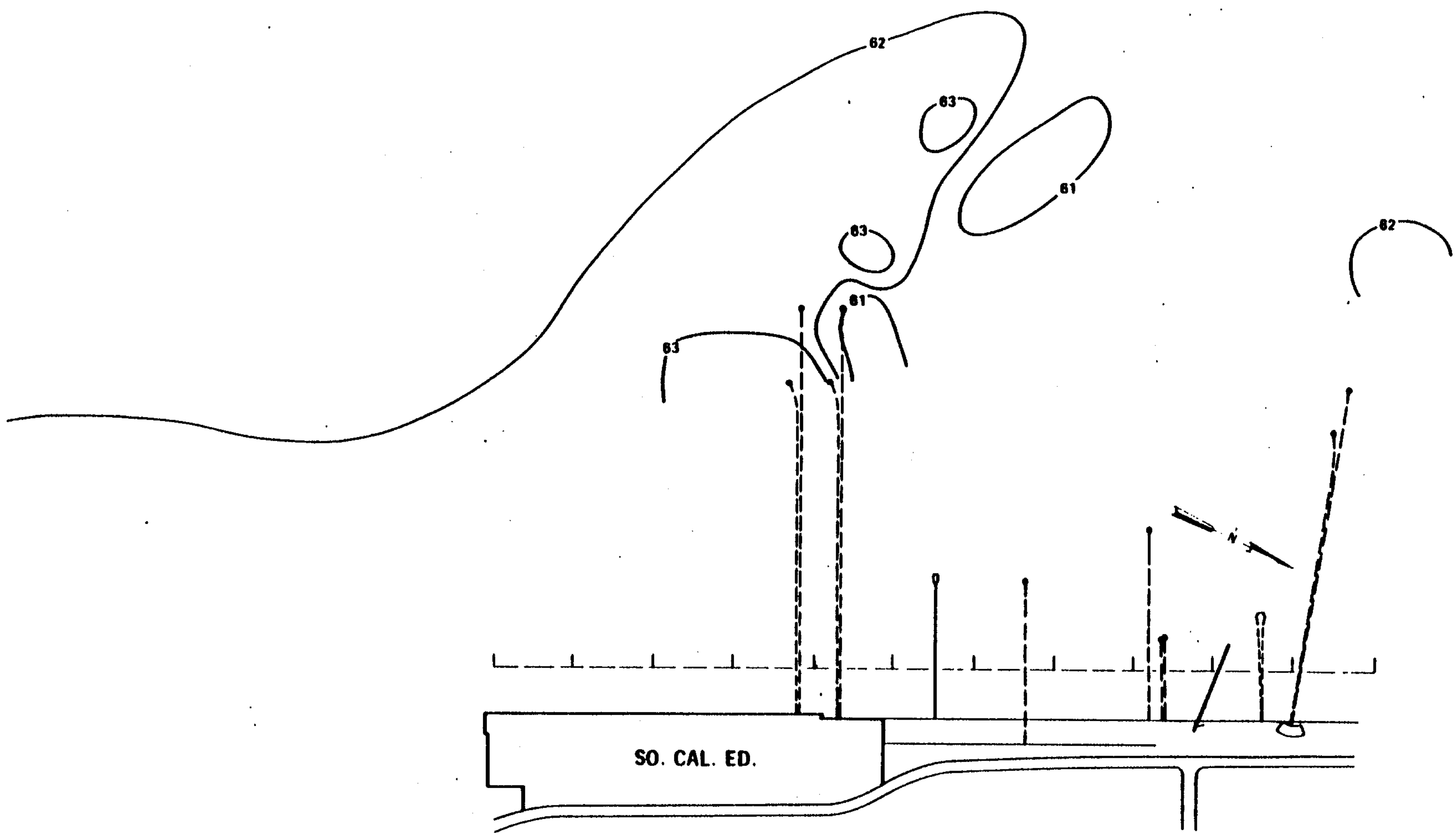

FIGURE II-A-30. THERMAL PATTERN, 8 FOOT DEPTH, 1254-1402

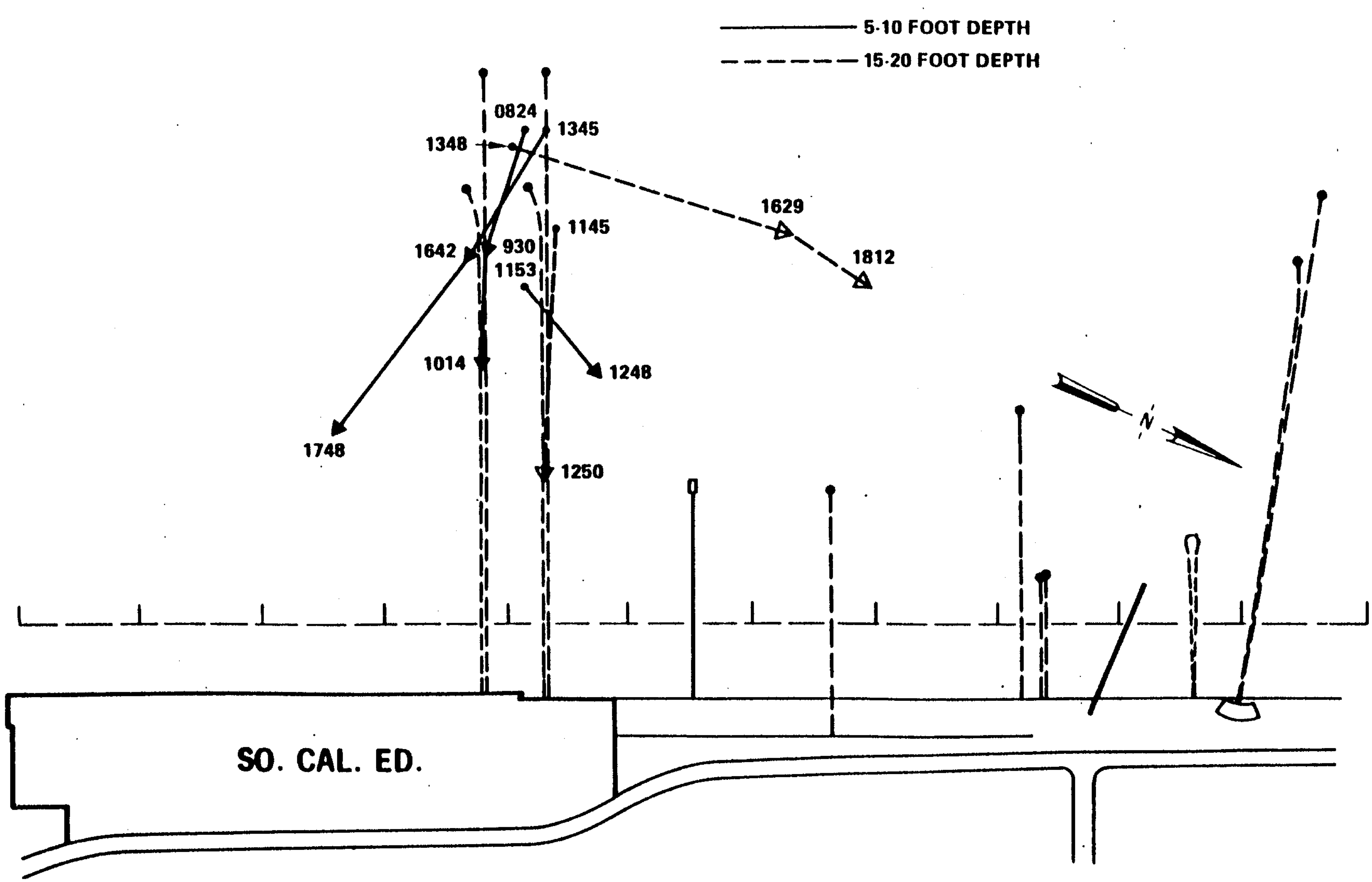

FIGURE II-A-32. TRACKS FOLLOWED BY DROGUES

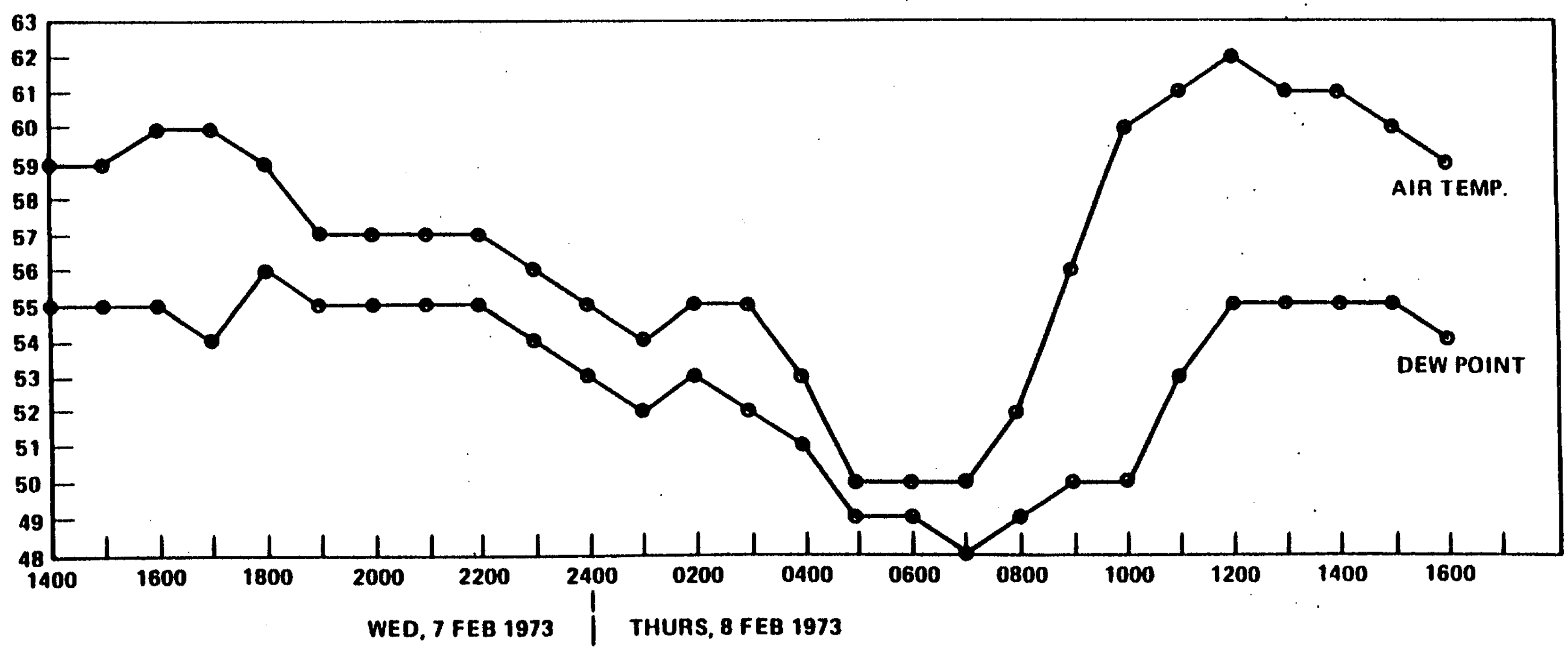

FIGURE II-A-34. WET AND DRY BULB TEMPERATURE

APPENDIX III-A

SYSTEMATIC CONSULTANTS

APPENDIX III-B

TAXONOMIC CHANGES MADE ON BENTHIC, TRAWL, AND DIVE SPECIES COLLECTED OVER THE STUDY PERIOD

Previous Name	Quarterly Survey where listed under previous name	Current Name
Glyceridae		
Glycera sp. (station 9, 1 ind.)	5/72	*Glycera convoluta*
Glycera sp.	8/72	*Glycera convoluta*
Glycera sp. juv. (stations 7, 8, 9)	11/72	*Glycera convoluta*
Glycera sp. (station 2, 1 ind.)	11/71	*Glycera* sp. juv.
Glycera sp. (stations 1, 3)	5/72	*Glycera* sp. juv.
Glycera sp. (station 9, 1 ind.)	11/71	*Glycera americana*
Glycera sp. (station 9, 2 ind.)	5/72	*Glycera americana*
Glycera convoluta	8/72	*Glycera americana*
Glycera sp. juv. (station 6)	11/72	*Glycera americana*
Goniadidae		
Glycinde sp.	5/72	*Goniada littorea*
Goniada sp.	11/71	*Goniada* sp. juv.
Glycera sp. (station 6)	5/72	*Glycinde polygnatha*
Magelonidae		
Magelona sp.	11/72	Unidentifiable fragment – delete
Magelona sp. (station 6)	11/72	*Magelona californica*
Magelona sp. (station 2)	11/72	*Magelona* sp. unid. juv.
Maldanidae		
Axiothella sp.	11/71, 8/72	*Praxiella affinis pacifica*
Praxillella affinis	5/72	*Praxiella affinis pracifica*
Maldanid, juv.	5/72	*Praxiella affinis pacifica*
Maldanid sp.	8/72	*Praxiella affinis pacifica*
Maldanidae sp.	11/72	*Praxiella affinis pacifica*
Nephtyidae		
Nephtys sp.	11/71, 8/72, 11/72	*Nephtys* sp. juv.
Nereidae		
Nereis sp.	5/72	*Nereis procesa*
Nereid sp.	8/72	*Nereis latescens*
Onuphidae		
Nothria iridescens	All surveys	*Nothria* sp.
Nothria elegans	All surveys	*Nothria* sp.
Nothria sp.	8/72, 11/72	*Nothria* sp. juv.
Onuphid. juv.	11/71, 5/72	*Onuphis* sp. juv.
Onuphis sp.	8/72	*Onuphis* sp. juv.
Orbiniidae		
Orbiniid sp.	11/71	unidentifiable fragment – delete
Paraonidae		
Aricidea suecica	8/72, 11/72	*Aricidea nr. suecica*
Paraonis gracilis	5/72	*Paraonis gracilis oculata*

Previous Name	Quarterly Survey where listed under previous name	Current Name
Macoma rexithaerus	8/72, 11/72	*Macoma (rexithaerus)* sp.
Protothaca staminea	All surveys	*Chione* cf. *californiensis*
Gastropoda		
Acteocina harpa	All surveys	*Acteocina* cf. *inculta*
Acteocina inculta	11/72	*Acteocina culcitella*
Gastropod sp. Z	5/72	*Rissoacea* juv.
Gastropod sp. A	8/72	*Rissoacea* juv.
Barleeia californica	11/72	*Rissoacea* juv.
Barleeia sp.	11/72	*Rissoacea* juv.
Mitrella carinata	All surveys	*Alia carinata*
Nassarina penicillata	All surveys	*Mangelia alesidota*
Nassarius perpinguis	All surveys	*Nassarius fossatus*
Nassarius sp.	8/72	*Nassarius fossatus*
Veliger, unid.	11/71	Planktonic form deleted
Epitonium sp. A	5/72, 8/72	*Epitonium* spp.
Odostomia nota	8/72	*Odostomia resina*
Vitrinella oldroydi	11/72, 8/72	Polychaete tube deleted
Ostracoda		
Ostracod sp. A.	11/71, 5/72, 8/72	*Euphilomedes longiseta*
Ostracod sp. C	11/71, 5/72	*Euphilomedes longiseta*
Ostracod sp. B	11/71, 5/72, 8/72	*Parasterope* sp. nov.
Cylindroleberis sp.	11/72	*Parasterope* sp. nov.
Ostracod sp. D	11/71	*Euphilomedes carcharodonta*
Pseudophilomedes sp.	11/72	*Euphilomedes carcharodonta*
Cumacea		
Eudorella pacifica	5/72, 8/72, 11/72	*Leptocuma formansi*
Cumacean sp. L	5/72, 8/72, 11/72	*Leptocuma formansi*
Colurostylis sp. A, B	11/72	*Cyclaspis* sp. B
Oxyurostylis sp. A, B	11/72	*Oxyurostylis pacifica*
Cumacean sp. E	11/72	Immature copepod deleted
Isopoda		
Ancinus sp. A	11/71, 5/72	*Ancinus seticomvus*
Ancinus depressa	8/72	*Ancinus seticomvus*
Ancinus sp.	11/72	*Ancinus seticomvus*
Isopod sp. A	11/71, 5/72	*Munna ubiquita*
Isopod sp. B	5/72	*Munna ubiquita*
Isopod sp. B	8/72	Shed skin deleted
Amphipoda		
Gammarid sp. A, I	11/71, 5/72	*Photis lacia*
Gammarid sp. B	11/71	*Ampelisca cristata*
Gammarid sp. S	5/72	*Ampelisca cristata*
Gammarid sp. C	11/71	Amphipod sp. C

Previous Name	Quarterly Survey where listed under previous name	Current Name
Amphipoda (cont.)		
Gammarid sp. D	11/71, 5/72	*Paraphoxus epistomus*
Gammarid sp. E	11/71, 5/72	*Synchelidium* sp.
Gammarid sp. K	5/72	*Synchelidium* sp.
Gammarid sp. Q, R	5/72	*Synchelidium* sp.
Ampelisca cristata (station 1, 1 ind.)	8/72	*Synchelidium* sp.
Gammarid sp. F	11/71, 5/72	*Argissa hamatipes*
Amphipod sp. 4, 7	11/72	*Argissa hamatipes*
Gammarid sp. G	11/71	*Tiron biocellata*
Gammarid sp. W	5/72	*Tiron biocellata*
Ampelisca cristata (station 1, 1 ind.)	8/72	*Tiron biocellata*
Gammarid sp. H	11/71, 5/72	*Paraphoxus* sp.
Gammarid sp. J	11/71	*Monoculodes hartmanae*
Oedicerotidae sp.		*Monoculodes hartmanae*
Gammarid sp. K	11/71	*Acuminodeutopis* sp.
Amphipod sp. 12	11/72	*Acuminodeutopis* sp.
Gammarid sp. N	5/72	Shed skin deleted
Gammarid sp. P	5/72	*Megaluropis* sp.
Amphipod sp. X	8/72	*Megaluropis* sp.
Amphipod sp. 10	11/72	*Megaluropis* sp.
Gammarid sp. T	5/72	*Erichthonius brasiliensis*
Gammarid sp. U	5/72	*Microjassa* sp.
Gammarid sp. V	5/72	*Gammaropsis* sp.
Amphipod sp. Y	8/72	*Parapleustes* sp.
Amphipod sp. 6	11/72	*Parapleustes* sp.
Amphipod sp. 3	11/72	*Listriella melanica*
Amphipod sp. 8	11/72	*Aoroides* sp.
Amphipod sp. 9	11/72	*Gammaropsis thompsoni*
Amphipod sp. 5	11/72	Tanaidacea sp.
Tanaidacea		
Tanaid sp. A, B	11/71	Tanaidacea sp.
Euphausiacea		
Euphausid sp. A	11/71	Euphausiacea sp.
Euphausid sp. A, B	8/72	Euphausiacea sp.
Mysidacea		
Mysidae sp.	11/72	Mysidacea sp.
Echinodermata		
Echinoid sp., juv.	All surveys	*Lytechinus* sp. juv.
Ophiuroid sp., juv.	All surveys	*Amphipholus* sp. juv.

DIVE SPECIES TAXONOMIC CHANGES

	Presently	Quarterly Survey where listed under previous name	Formerly
1	*Aglaophenia* sp.	All surveys	Consists of 2 species: *A. dispar*, and *A. strathionides*
2	*Campanularia verticillata*	11/71, 5/72, 8/72	Formerly called *Garvea*
3	*Ancinus seticomvus*	8/72	*Ancinus* sp.
4	*Cancer anthonyi*	8/72	*C. productus*
5	*Pyromaia tuberculata*	11/71, 8/72	*Inachoides tuberculatus*
6	*Alia carinata*	8/72, 11/72	*Mitrella carinata*
7	*Mangelia alesidota*	8/72	*Nassarina penicilata*
8	*Nassarius fossatus*	All surveys	*Nassarius perpinguis*
9*	*Thalamoporella californica*	8/72	Listed as Coelenterata, should be Ectoprocta

*Footnote numbers referred to in text tables

TRAWL SPECIES TAXONOMIC CHANGES

	Presently	Quarterly Survey where listed under previous name	Formerly
1*	*Aglaophenia* sp.	All surveys	Consists of 2 species *A. dispar*, and *A. strathionides*
2	*Campanularia verticillate*	11/71	*Garvea* sp.
3	*Cancer anthonyi*	11/71, 5/72, 8/72	*C. productus*
4	*Pyromaia tuberculata*	11/72	*Inachoides tuberculatus*
5	*Alia carinata*	All surveys	*Mitrella carinata*
6	*Lironica vulgaris*	11/71, 5/72, 8/72	*Lironica californica*

*Footnote numbers referred to in text tables

APPENDIX III-C

BENTHIC INVERTEBRATE SPECIES ENCOUNTERED DURING THE STUDY PERIOD AND THEIR NUMERICAL ABUNDANCE FOR EACH QUARTERLY SURVEY

Southern California Edison Company

EL SEGUNDO GENERATING STATION

THERMAL EFFECT STUDY

FINAL REPORT 1973

MARINE BIOLOGY RESEARCH GROUP
ELECTROCHEMISTRY DEPARTMENT
LOCKHEED AIRCRAFT SERVICE COMPANY
A Division of Lockheed Aircraft Corporation
LOCKHEED OCEAN LABORATORY-SAN DIEGO, CALIFORNIA

D. KAY 22149

CLASSIFICATION SPECIES	NOV. 1971	MAY 1972	AUG. 1972	NOV. 1972
Foraminifera				
Alveolophragmium columbiensis	1	0	10	11
Cribroelphidium spinatum	3	24	48	75
Florilus scaphus	0	1	4	3
Foram sp. B	0	0	4	3
Foram sp. C	0	0	1	4
Foram sp. E	0	0	0	3
Quinqueloculina seminulum	9	21	51	91
Trochammina pacifica	83	246	501	813
Triloculina trigonula	0	17	1	0
Foram sp. D	0	0	1	0
Elphidium sp.	0	1	5	0
Labrospira columbiensis	0	4	0	0
Labrospira sp.	0	0	0	1
Elphidium articulatum	0	2	0	0
Foram sp. A	0	0	1	0
Coelenterata				
Anthozoa sp.	0	0	3	4
Edwardsiella californica	0	16	1	0
Renilla kollikeri	1	0	0	0
Stylatula elongata	3	0	0	0
Platyhelminthes				
Flatworm spp.	23	37	2	8
Nemertea				
Nemertean spp.	325	221	122	124
Nematoda				
Amphiporus bimaculatus	0	0	1	0
Nematode spp.	262	281	271	276
Polychaeta				
Family Ampharetidae				
Ampharete arctica	1	0	0	0
Ampharetidae juv.	5	9	5	13
Amphicteis scaphabranchiata	3	0	0	4
Ampharete labrops	0	0	2	2
Amphicteis glabra	0	0	3	1
Family Capitellidae				
Capitita ambiseta	221	130	89	227
Notomastus tenuis	2	2	2	15
Mediomastus ? acutus	9	1	13	24
Anotomastus gordiodes	2	0	0	0
Capitella capitata	0	0	1	0
Capitellidae sp. unid. juv.	0	0	0	1
Decamastus gracilis	0	0	0	9

CLASSIFICATION SPECIES	NOV. 1971	MAY 1972	AUG. 1972	NOV. 1972
Polychaeta (cont.)				
Family Chaetopteridae				
Telepsarus costarum	18	1	11	38
Family Cirratulidae				
Chaetozone corona	66	90	28	289
Tharyx spp.	70	57	46	92
Cirratulidae sp. unid. juv.	0	0	0	1
Cirriformia sp. unid. juv.	0	0	0	1
Family Glyceridae				
Glycera capitata	2	5	0	1
Glycera convoluta	6	2	4	6
Glycera sp. juv.	1	3	0	0
Glycera americana	1	2	1	1
Family Goniadidae				
Glycinde arminger	2	0	0	0
Glycinde sp. juv.	4	0	0	0
Goniada brunnea	1	1	1	1
Goniada littorea	4	4	2	1
Goniada sp. juv.	8	0	0	1
Glycinde polygnatha	0	10	6	11
Goniada acicula	0	0	1	3
Family Hesionidae				
Hesionella mccullochae	4	0	12	0
Ophiodromus pugettensis	7	7	22	14
Gyptis arenicola glabra	0	0	0	1
Family Lumbrineridae				
Lumbrineris sp. juv.	58	2	7	190
Lumbrineris tetraura	115	101	110	0
Family Magelonidae				
Magelona pacifica	1	0	0	0
Magelona sacculata	42	244	102	0
Magelona californica	0	0	0	9
Magelona sp. unid. juv.	0	0	0	1
Family Maldanidae				
Praxillella affinis pacifica	12	9	4	5
Axiothella rubrocincta	0	0	8	2
Family Nephtyidae				
Nephtys caecoides	65	22	31	9
Nephtys californiensis	13	7	57	18
Nephtys cornuta franciscana	78	220	274	50

CLASSIFICATION SPECIES	NOV. 1971	MAY 1972	AUG. 1972	NOV. 1972
Polychaeta (cont.)				
Family Nephtyidae (cont.)				
Nephtys sp. juv.	19	6	4	1
Nephtys parva	0	10	0	0
Family Nereidae				
Nereis procesa	5	1	0	0
Nereis latescens	0	0	1	0
Family Onuphidae				
Diopatra sp.	1	0	2	0
Nothria sp.	21	24	10	23
Nothria sp. juv.	4	0	2	3
Onuphis sp. juv.	13	0	3	0
Onuphis eremita	4	0	0	0
onuphidae sp. juv.	0	1	2	8
Diopatra splendidissima	0	0	1	0
Diopatra ornata	0	1	0	0
Family Opheliidae				
Armandia bioculata	729	4	552	4
Family Orbiniidae				
Haploscoloplos elongatus	2	9	21	31
Family Oweniidae				
Owenia collaris	0	0	1	0
Family Paraonidae				
Aricidea nr. *fauveli*	79	1	0	0
Paraonis gracilis oculata	3	12	0	0
Aricidea nr. *suecica*	0	60	42	40
Paraonides platybranchia	0	0	41	6
Family Pectinariidae				
Pectinaria californiensis	30	103	198	27
Family Phyllodocidae				
Anaitides williamsi	29	31	14	13
Eteone californica	10	3	3	9
Eumida sanguinea	12	1	0	2
Eteone nr. *lighti*	8	2	1	5
Genetyllis castanea	0	1	0	2
Phyllodocidae sp. unid. juv.	0	0	6	3

CLASSIFICATION SPECIES	NOV. 1971	MAY 1972	AUG. 1972	NOV. 1972
Polychaeta (cont.)				
Family Pilargiidae				
Pilargis berkeleyi	0	1	1	4
Sigambra nr. *tentaculata*	0	1	1	2
Pilargidae unid.	0	0	1	0
Sigambra bassi	0	0	0	1
Family Poecilochaetidae				
Poecilochaetus johnsoni	8	2	0	0
Family Polynoidae				
Polynoidae unid.	15	12	8	1
Halosydna johnsoni	0	0	1	0
Family Sabellidae				
Euchone incolor	5	5	6	8
Chone sp.	4	0	0	0
Chone mollis	0	1	3	1
Family Sigalionidae				
Sthenelais verruculosa	1	6	0	2
Pholoe glabra	0	9	0	0
Thalenessa spinosa	0	0	0	4
Family Spionidae				
Laonice cirrata	2	0	0	0
Nerine cirratulus	1	0	0	0
Nerinides acuta	20	26	13	14
Polydora sp. juv.	2	0	0	0
Prionospio pinnata	6	7	1	25
Prionospio pygmaeus	1093	660	764	435
Spiophanes bombyx	68	36	51	41
Spiophanes fimbriata	1	0	0	0
Spiophanes missionensis	3	2	6	6
Laonice foliata	0	2	0	0
Prionospio malmgremi	0	1	0	1
Prinospio cirrifera	0	0	6	0
Family Sphaerodoridium				
Sphaerodoridium biserialis	0	2	0	0
Family Syllidae				
Typosyllis ? Hyalina	44	14	14	10
Exogone lourei	0	1	1	4
Typosyllis fasciata	0	11	6	9
Polydora limicola	0	0	4	1
Polydora ligni	0	0	4	2
Sphaerosyllis pirifera	0	0	1	0

CLASSIFICATION SPECIES	NOV. 1971	MAY 1972	AUG. 1972	NOV. 1972
Polychaeta (cont.)				
Family Syllidae (cont.)				
Syllidae unid. juv.	0	0	1	1
Exogone gemmifera	0	0	0	1
Polydora nuchalis	0	0	0	1
Sphaerosyllis californiensis	0	0	0	1
Typosyllis sp.	0	0	0	31
Polydora sp. unid. juv.	0	0	0	0
Family Terebellidae				
Amaeana occidentalis	19	0	0	0
Terebellidae unid. juv.	2	1	0	1
Lamellibranchia				
Donax cf. *gouldii*	0	0	0	1
Modiolus capax	1	0	5	1
Siliqua lucida	3	1	3	1
Siliqua sp. juv.	7	1	1	0
Tellina modesta	1179	1200	623	580
Solen rosaceus	0	0	2	0
Leptopecten sp.	3	0	0	0
Chione undatella	31	6	11	9
Lyonsia sp.	4	0	0	5
Macoma (rexithaerus) juv.	41	47	77	53
Chione cf. *californiensis*	0	1	1	3
Psephidia sp.	19	11	0	2
Tresus nuttalli	81	7	124	4
Gastropoda				
Acteocina cf. *inculta*	47	85	54	57
Acteocina culcitella	0	0	4	11
Acteon punctocaelatus	5	4	11	2
Rissoacea juv.	0	2	5	7
Caecum crebricinctum	0	0	0	1
Cylichna diegensis	20	2	3	5
Alia carinata	0	6	13	4
Mangelia alesidota	19	18	22	22
Amphithalmus lacunatus	0	0	1	0
Epitonium sp.	0	2	2	0
Nassarius fossatus	20	10	63	23
Odostomia resina	20	80	200	117
Olivella biplicata	295	133	175	281
Polinices lewisii	0	1	4	4
Sulcoretusa xystrum	33	57	19	41
Turbonilla castanea	2	1	9	3
Turbonilla cf. *kelseyi*	20	93	87	103

CLASSIFICATION SPECIES	NOV. 1971	MAY 1972	AUG. 1972	NOV. 1972
Gastropoda (cont.)				
Kurtziella plumbea	1	0	0	0
Polinices reclusiana	3	0	0	0
Rissoina dalli	4	0	0	3
Terebra pedroana	1	0	0	0
Volvulella cylindrica	19	9	13	9
Opisthobranchia				
Opisthobranchia unid. juv.	1	2	3	2
Haminoea virescens	2	0	0	0
Scaphopoda				
Cadulus fusiformis	1	2	0	1
Scaphopod sp. A	0	1	5	0
Pyonogonida				
Callipallene californiensis	39	15	23	8
Oropallene palpida	119	2	10	2
Pyonogonida unid. juv.	68	2	3	7
Ostracoda				
Euphilomedes longiseta	1338	224	88	16
Euphilomedes carcharodonta	50	0	0	3
Parasterope sp. nov.	32	318	45	30
Cirripedia				
Mitrella polymerus	0	0	1	0
Isopoda				
Ancinus seticomvus	9	27	22	34
Edotea sublittoralis	30	85	20	32
Munna ubiquita	9	75	24	16
Lironeca californica	0	1	0	0
Amphipoda				
Acuminodeutopus sp.	1	0	0	15
Ampelisca cristata	2	1	0	7
Aoroides sp.	0	0	0	1
Argissa hamatipes	8	17	8	27
Erichthonius brasiliensis	0	1	0	1
Gammaropsis thompsoni	0	0	0	1
Gammaropsis sp.	0	1	0	.0
Listriella melanica	0	0	0	1
Megaluropus sp.	0	1	1	6
Microjassa sp.	0	1	0	0
Monoculodes hartmanae	1	4	5	27
Paraphoxus epistomus	7	4	10	17
Paraphoxus sp.	3	3	0	4

CLASSIFICATION SPECIES	NOV. 1971	MAY 1972	AUG. 1972	NOV. 1972
Amphipoda (cont.)				
Parapleustes sp.	0	0	5	2
Photis lacia	6	16	17	11
Synchelidium spp.	9	66	84	31
Tiron biocellata	3	0	4	1
Amphipod C	1	0	0	0
Cumacea				
Campylaspis sp. A	5	2	0	6
Campylaspis hartae	5	1	0	0
Campylaspis rubromoculata	1	0	0	0
Cyclaspis sp. B	65	51	4	4
Cyclaspis sp. C	4	8	1	0
Cumella sp.	16	13	11	2
Leptocuma formansi	13	3	92	5
Diastylopsis tenuis	127	63	13	68
Lamprops carinata	10	32	12	8
Oxyurostylis pacifica	1	0	0	2
Cumacean sp. M	0	0	2	0
Cumacean sp. N	0	0	1	0
Tanaidacea				
Tanaidacea sp.	4	0	0	3
Mysidae				
Mysidacea sp.	0	0	0	3
Euphausiacea				
Euphausiacea sp.	1	0	2	0
Decapoda				
Cancer sp. juv.	0	0	0	1
Lepidopa myops	2	2	2	3
Pinnixia longipes	0	0	0	1
Pinnixia sp. juv.	0	0	0	4
Ophisthus transversus	1	0	0	0
Pagurus samuelis	0	3	0	0
Cancer gracilis	0	0	1	0
Phoronida				
Phoronida unid.	0	0	0	3
Echinodermata				
Astropecten armatus	0	0	1	1
Lytechinus sp. juv.	20	102	41	12
Amphipholis sp. juv.	89	14	4	99
Holothuroid sp.	0	1	0	0

CLASSIFICATION SPECIES	NOV. 1971	MAY 1972	AUG. 1972	NOV. 1972
Enteropneusta				
Balanoglossus sp.	0	0	0	1
Enteropneusta unid. sp.	0	0	0	2
Brachiopoda				
Glottidia albida	2	0	1	0

APPENDIX III-D

SUMMARY OF BENTHIC SEDIMENT TEMPERATURES TAKEN DURING EACH QUARTERLY SURVEY

APPENDIX III-E

**FISH SPECIES TRAWLED DURING THE STUDY:
COMMON AND SCIENTIFIC NAMES**

Scientific Name	Common Name
Scorpaenidae	
Scorpaena guttata (Girard)	California scorpionfish
Sebastes auriculatus (Girard)	Brown rockfish
Sebastes miniatus (Jordan and Gilbert)	Vermilion rockfish
Sebastes paucispinis (Ayres)	Bocaccio
Cottidae	
Artedius notospilotus (Girard)	Bonehead sculpin
Leptocotus armatus (Girard)	Pacific staghorn sculpin
Agonidae	
Odontopyxis trispinosa (Lockington)	Pygmy poacher
Bothidae	
Citharichthys stigmaeus (Jordan and Gilbert)	Speckled sanddab
Paralichthys californicus (Ayres)	California halibut
Pleuronectidae	
Glyotocephalus zachirus (Lockington)	Rex sole
Hypsopsetta guttulata (Girard)	Diamond turbot
Parophrys vetulus (Girard)	English sole
Pleuronichthys coenosus (Girard)	C.O. sole
Pleuronichthys decurrens (Jordan and Gilbert)	Curlfin sole
Pleuronichthys ritteri (Starks and Morris)	Spotted turbot
Pleuronichthys verticalis (Jordan and Gilbert)	Hornyhead turbot
Cynoglossidae	
Symphurus atricauda (Jordan and Gilbert)	California tonguefish

APPENDIX III-F

LENGTH-FREQUENCY DISTRIBUTIONS OF DOMINANT FISHES

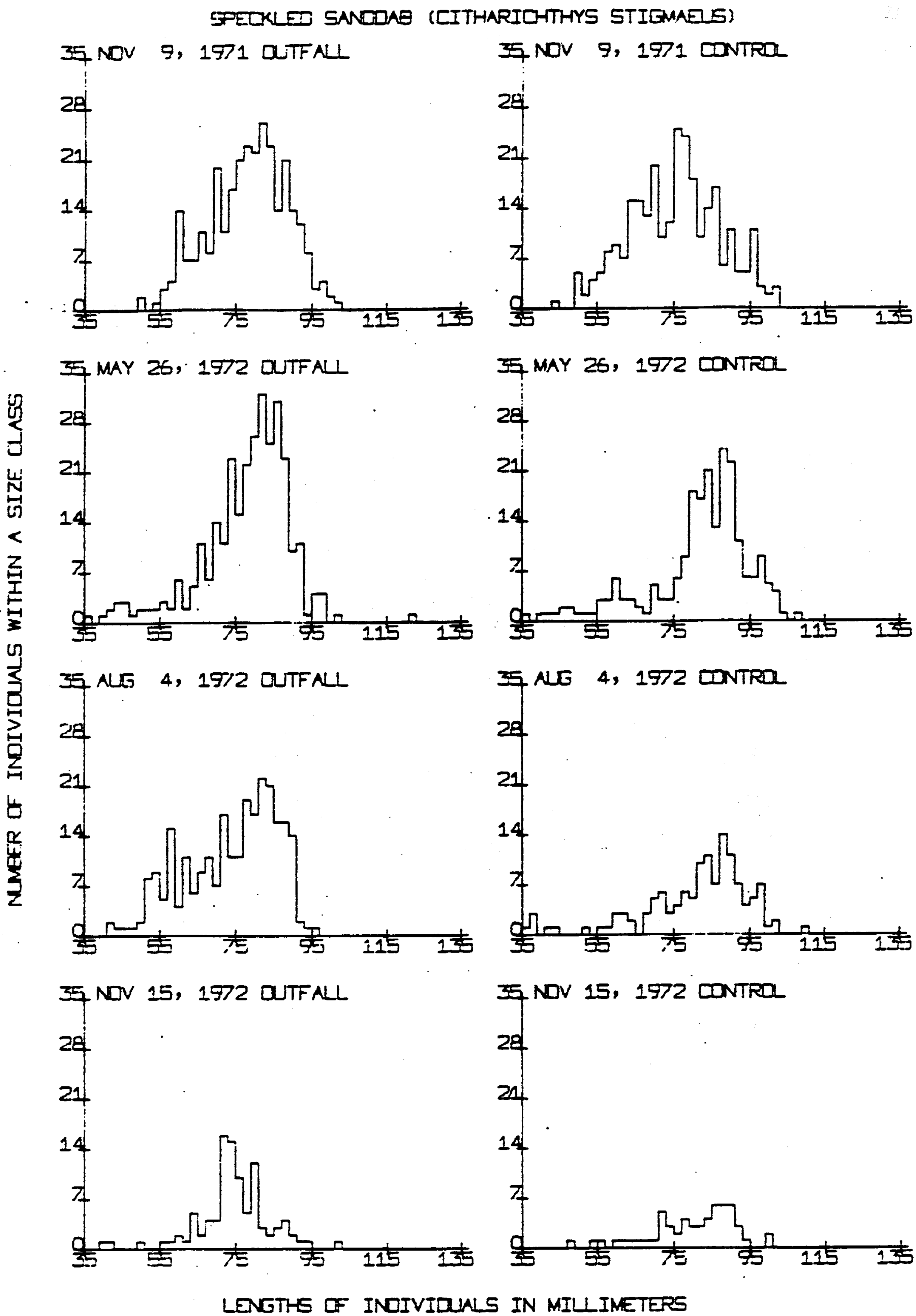

FIGURE III-F-2. LENGTH-FREQUENCY DISTRIBUTION OF *CITHARICHTHYS STIGMAEUS* FOR EACH SURVEY PERIOD

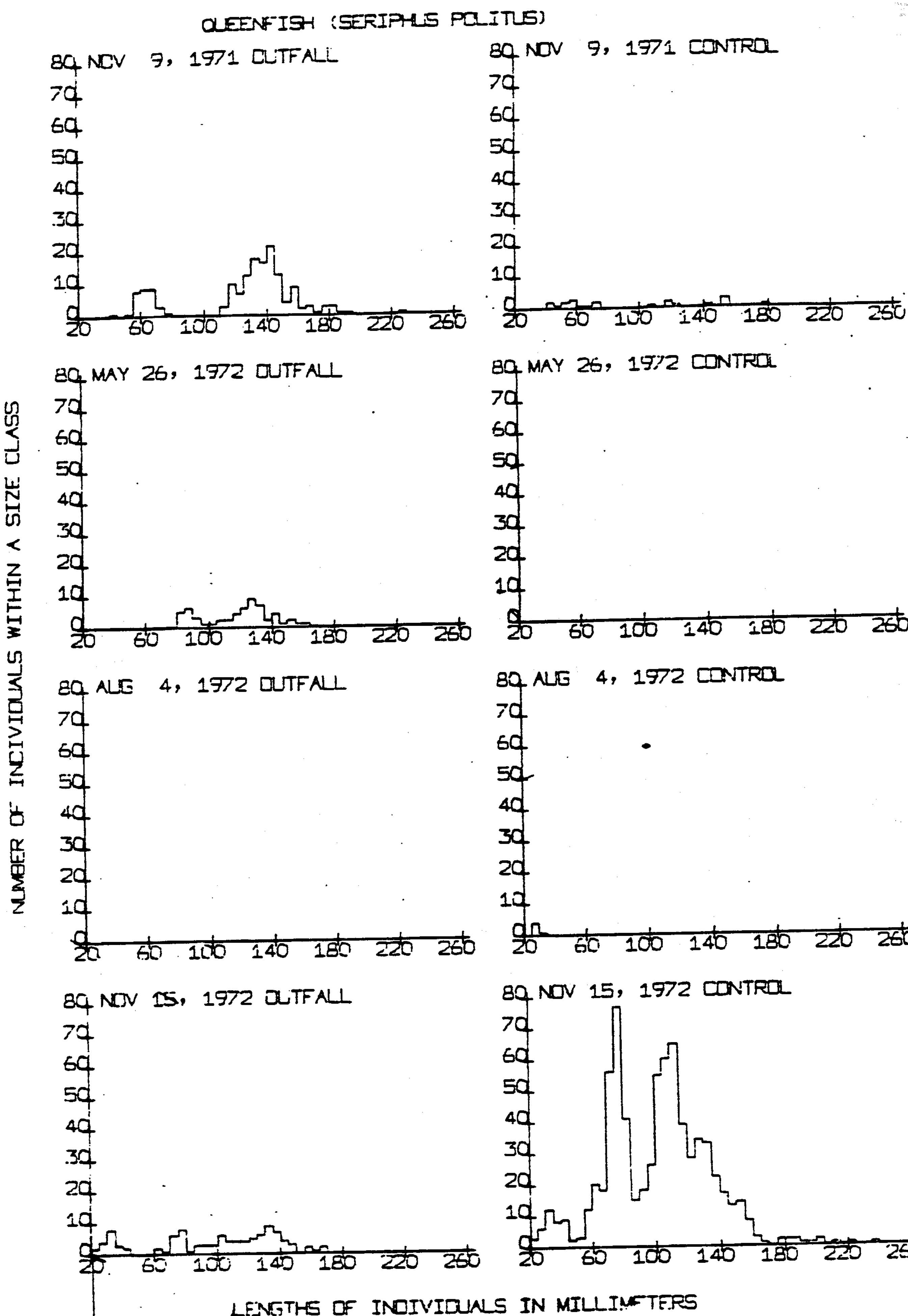

FIGURE III-F-4. LENGTH-FREQUENCY DISTRIBUTION OF *SERIPUS POLITUS* FOR EACH SURVEY PERIOD

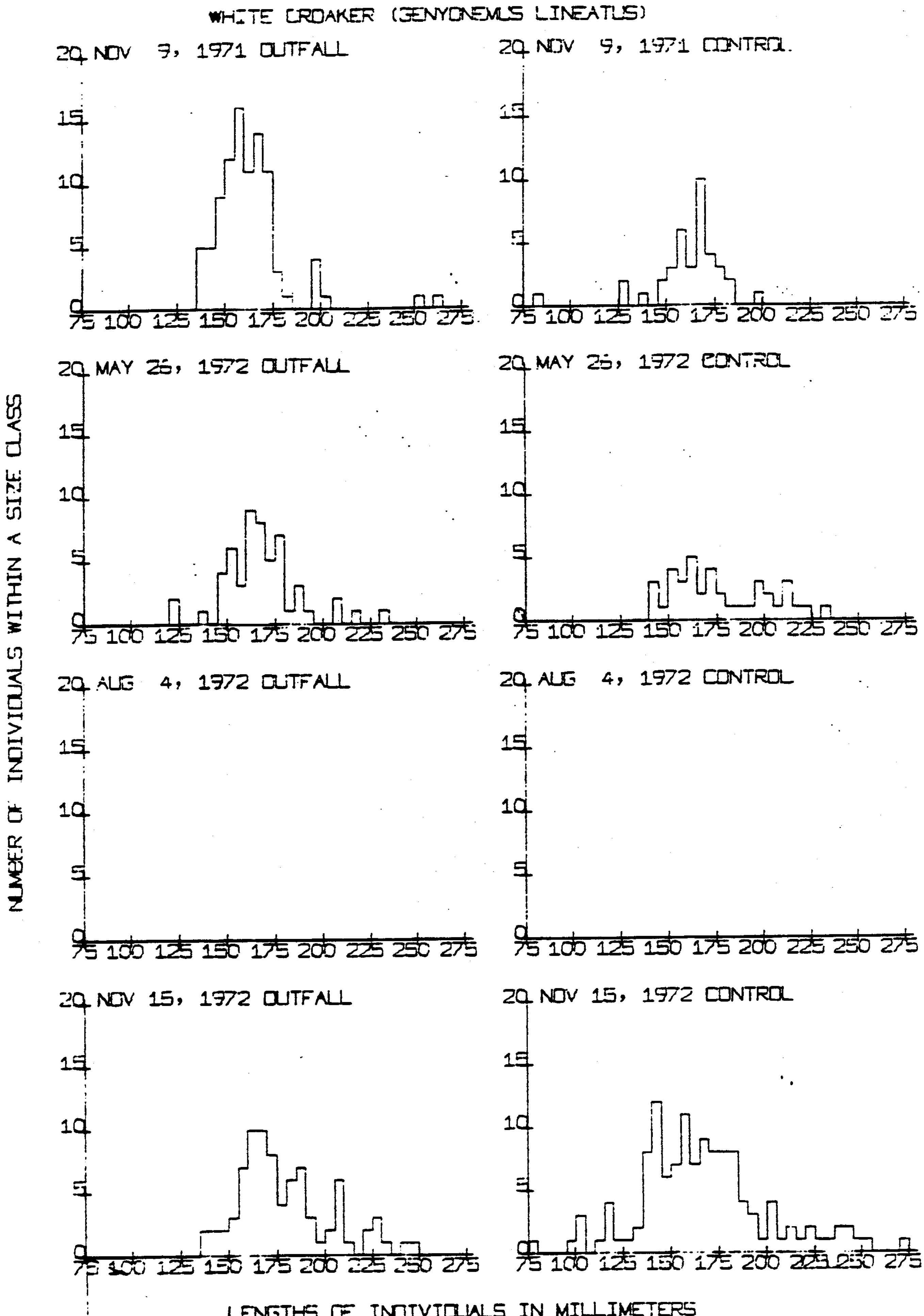

FIGURE III-F-6. LENGTH-FREQUENCY DISTRIBUTION OF *GENYONEMUS LINEATUS* FOR EACH SURVEY PERIOD

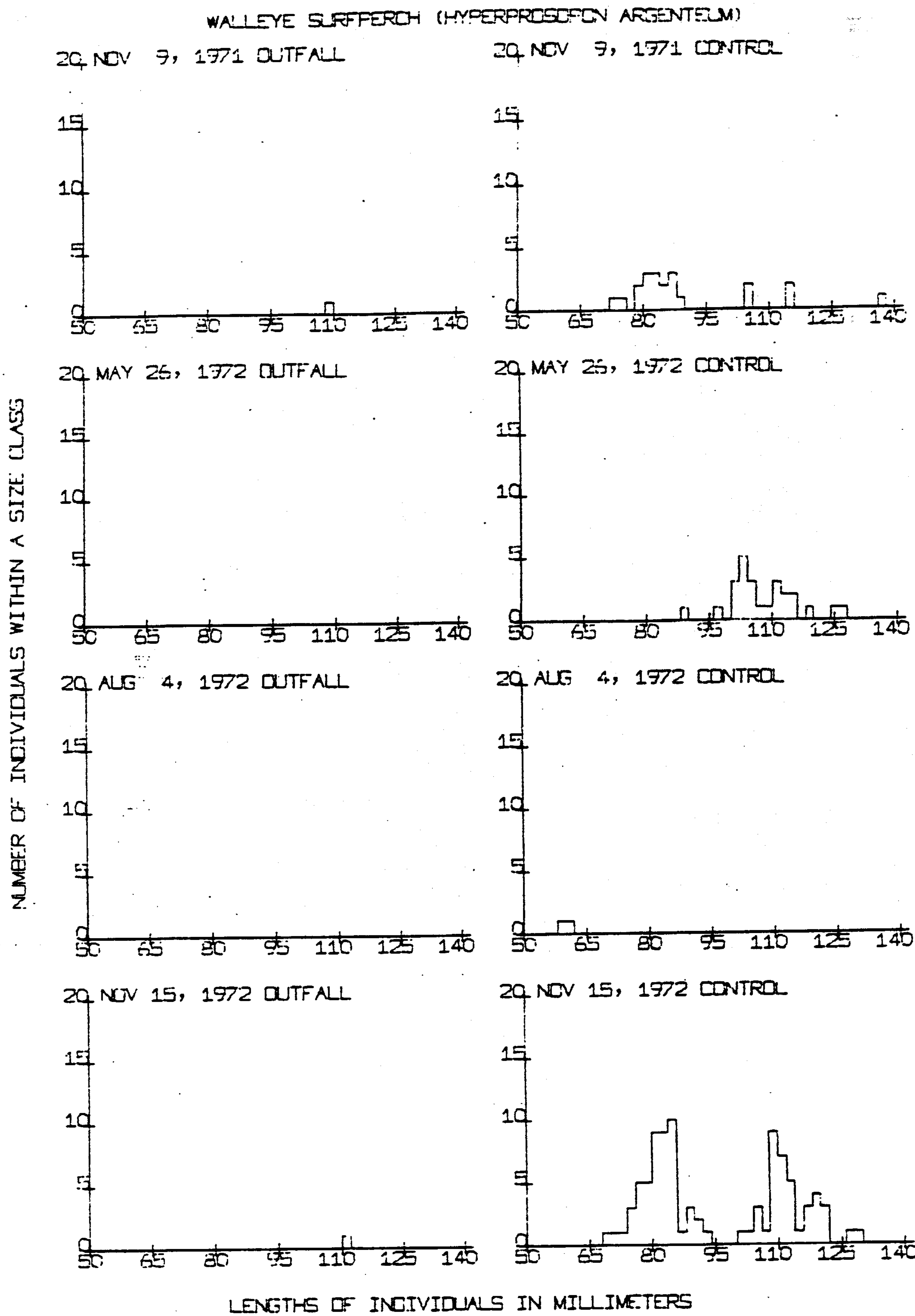

FIGURE III-F-8. LENGTH-FREQUENCY DISTRIBUTION OF *HYPERPROSOPON ARGENTEUM* FOR EACH SURVEY PERIOD

APPENDIX III-G

COMMON AND SCIENTIFIC NAMES OF MACRO-INVERTEBRATES RECORDED DURING THE DIVE SURVEYS

ECTOPROCTA		
Class Gymnolaemata		
Thalamoporella californica		Bryozoan
ECHINODERMATA		
Class Asteroidea		
Astropecten armatus		Southern sandstar
Petalaster foliolata		
Pisaster brevispinus		Pink starfish